# ATTACHMENT J.4.29

# OPERABLE UNIT 4 CONCEPTUAL DESIGN PLAN FOR

# RESIDUE RETRIEVAL SYSTEM FOR THE FERNALD SUPERSTRUCTURE

# Operable Unit 4
# Conceptual Design Plan
# for
# Residue Retrieval System for the Fernald Residues Vitrification Plant Silo Superstructure

Fernald Environmental Management Project

Project No. 40200
March 1996
Revision No. 0

U.S. Department of Energy
Fernald Area Office

# Conceptual Design Plan for Residue Retrieval Systems for the Fernald Residues Vitrification Plant

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# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| ALARA | As Low As Reasonably Achievable |
| D&D | Decontamination and Decommissioning |
| DCS | Distributed Control System |
| DOE | United States Department of Energy |
| EE | Equipment Enclosure |
| ER | Equipment Room |
| FEMP | Fernald Environmental Management Project |
| FERMCO | Fernald Environmental Restoration Management Corporation |
| FRVP | Fernald Residues Vitrification Plant |
| gpm | gallons per minute |
| HEPA | High-Efficiency Particulate Air |
| ID | Inside Diameter |
| ksi | kips per square inch |
| mph | miles per hour |
| NEMA | National Electrical Manufacturers Association |
| NRTS | New Radon Treatment System |
| OSDF | On-Site Disposal Facility |
| OU | Operable Unit |
| PDCU | Power Distribution and Control Unit |
| psf | pounds per square foot |
| psi | pounds per square inch |
| RDWP | Remedial Design Work Plan |
| ROD | Record of Decision |
| RTS | Radon Treatment System |
| TMADS | Tether Management and Deployment System |

# SECTION 1

# INTRODUCTION AND PURPOSE

## 1.1 Introduction

The Fernald Environmental Management Project (FEMP) established operations in 1951 under orders of the Atomic Energy Commission and produced uranium and other metals for use at other United States Department of Energy (DOE) facilities. Production at the FEMP has ceased and the environmental remediation of the entire site is ongoing. To aid in the remediation effort, the FEMP is separated into five operable units (OUs). OU-4 is on the west-central boundary of the FEMP and includes four silos: Silos 1 and 2 (also known as the K-65 Silos), Silo 3, and Silo 4. Silos 1 and 2 contain radium-bearing residues from pitchblende ore processes. Silo 3 contains dry uranium oxide and other metal oxides. Silo 4 is empty and has never been used.

The treatment technology selected for processing the silo contents is vitrification. This process converts material into a chemically inert glass, encapsulating the radiological constituents and reducing radon gas emissions. The Fernald Residues Vitrification Plant (FRVP) project has been established to accomplish this objective. In accordance with the OU-4 Remedial Design Work Plan (RDWP), the design of the FRVP has been divided into discrete work packages to allow a phased approach to design and construction. This is done with the objective of satisfying the Comprehensive Environmental Response, Compensation, and Liability Act, Section 120(e)(2) and ensuring that substantial, physical, and continuous remedial activities for OU-4 can be initiated and sustained.

To treat (vitrify) the silo residues, they must be removed from the silos and transported to the treatment facility. Residue retrieval systems will be designed and constructed for this purpose. The current design approach includes the construction of superstructures over Silos 1 and 2 to be used as support platforms for the residue retrieval systems. The residues in Silo 3 will be accessed through new silo penetrations at grade level. In accordance with the phased design approach, identified in the RDWP (DOE 1995c), the superstructures and foundations will be designed and built early in the FRVP design before other elements of the design are complete. To ensure the adequacy of the final superstructure and foundation design, however, the design of the residue retrieval systems must proceed to the extent necessary to identify the types, sizes, and weights of the retrieval system components which the superstructures and foundations must support. Additionally, enough must be understood of the proposed operational philosophy to determine the operational space requirements and to address the necessary health and safety concerns for the workers who may require access to the superstructures and removal equipment. Therefore, the design of the superstructures, their Equipment Rooms (ERs), and the Silo 3 Equipment Enclosures (EEs) will consider shielding and ventilation required to protect workers.

## 1.2 Purpose

This Conceptual Design Plan is issued as part of the Conceptual Design Package for the Residue Retrieval Systems for the FRVP. The package consists of this plan and the full size conceptual drawings. An 11 by 17 inch copy of the drawings are included in Appendix A of this plan for information. The purpose of this plan is to provide background information and justification for the development of the overall conceptual design. When reviewed in conjunction with the conceptual design drawings it will provide the reader with an understanding of why specific elements of the design were selected and how the overall design works to satisfy the functional requirements of the project. This understanding is important due to the phased approach for design of the FRVP. The residue retrieval preliminary design has been developed to allow the development of a detailed design of the silo superstructures. To ensure that the superstructures will be able to accommodate the residue retrieval systems in the future (when their detailed design is completed), it is necessary to document the elements of the conceptual residue retrieval design which affected decisions in the detailed design for the silo superstructures. The same is true for the subsequent design of the New Radon Treatment System (NRTS) and the eventual detailed design of the FRVP building itself.

The Conceptual Design Package provides the necessary information to allow the development of a prefinal design for the construction of the superstructures and foundations to support the residue retrieval systems for Silos 1 and 2, and foundations and enclosures to support the Silo 3 system.

## 1.3 Design Guidance

The following documents were used as guidance and information in the generation of the conceptual design plan.

1) Remedial Investigation and Feasibility Studies (DOE 1993a, DOE 1994)
2) Record of Decision (ROD) (DOE 1994)
3) Functional Requirements Document (DOE 1995a)
4) Design Criteria Package (DOE 1995b)

## 1.4 Document Organization

This Conceptual Design Plan presents the conceptual design which has been developed for Silos 1 and 2 (K-65 Silos) and Silo 3 (Metal Oxides). The K-65 hydraulic residue retrieval system is discussed in Section 2 of this document while the Silo 3 pneumatic retrieval system is discussed in Section 3.

Drawing No. SK-X-04163 in Appendix A lists the drawings associated with the conceptual design package. These drawings are also referenced appropriately within the individual text sections.

The conceptual design for the residue retrieval systems is divided into subsystems. Each subsystem will be designed to satisfy a separate set of functional requirements. The description of each subsystem is provided to assist in understanding the concepts presented by the conceptual design package. Vendor/Manufacturer Drawings, catalog cuts, and sketches are provided in Appendix B to further illustrate the concepts developed in this document.

Appendix C provides a preliminary dose estimate for installation and normal residue retrieval operations/maintenance on the Silo 1 and 2 Superstructures and Equipment Rooms (ERs), and the side access Equipment Enclosures (EEs) for Silo 3.

# SECTION 2

# HYDRAULIC RETRIEVAL OF K-65 RESIDUES

Silos 1 and 2, the K-65 Silos, contain a total of 8,005 cubic yards of K-65 residues generated from the processing of high grade uranium ore (DOE 1994). The silos are large, cylindrical, above-grade, concrete vessels with post tensioned steel reinforcing. Each of the domed silos is 80 feet in diameter, 36 feet high at the center of the silo, and 26 feet high at the silo wall. An earthen berm surrounds the K-65 silo walls up to the outer edge of the silo dome. The berm was added to counterbalance the outward load from the silo contents and has a 3H:1V slope extending approximately 80 feet from the silo walls. The domes of the K-65 silos have five major manways. Four 20-inch flanged openings are located on a circle 25 feet from the center of the dome. A fifth 20-inch manway is located approximately 4 feet off center of the middle of the dome. For more detailed information on the K-65 silos see the Remedial Investigation Report (DOE 1993).

Two separate and independent retrieval systems will be developed and built for Silos 1 and 2 (DOE 1995a). A new larger opening will be cut in the center of the silo dome to accommodate this retrieval equipment. The retrieval systems utilize a submersible slurry pump with an integral spray ring and submerged jet nozzle deployed through the center opening. The equipment is lowered from an ER which is mounted within a superstructure over the center of the silo. The ER is connected to the silo headspace via a cylindrical containment insert which prevents the release of residue to the environment. The retrieval equipment passes through this containment insert to enter the silo headspace from the ER. Two remotely operated single point sluicing jets are mounted in two of the outer manways to assist in slurrying the residues for retrieval. A hydraulically powered, track driven, vehicle (Houdini) supplements the retrieval systems and can be deployed through the enlarged center manway of either silo to aid in discrete object management and removal of any residue remaining following slurry pumping.

A Radon Treatment System ventilates the silo headspace through piping connected to the manways. This system removes radon to lower the headspace concentration to limit personnel exposure, maintain a negative pressure in the silo, and ensure directional airflow from the ER into the silo headspace.

Drawings SK-M-04094 and SK-M-04095 (Appendix A) provide a plan and elevation view of the proposed silo superstructure and silo dome. The various subsystems which comprise the overall residue retrieval system are discussed in more detail in the following sections. Drawing SK-X-04163 (Appendix A) provides an index of the Preliminary Design Drawings which have been developed in support of this effort. These drawings are referenced throughout the subsystem descriptions.

## 2.1 Hydraulic Retrieval System

### 2.1.1 Functions Provided

Slurry Residue

Break up residue material and form a pumpable slurry at a rate to sustain retrieval operations.

Remove Slurry

Remove slurry from the silo and transfer it to the FRVP for dewatering to support a glass production rate of 24 tons per day. Each Silo Hydraulic Retrieval System will support 100 percent of the total FRVP glass production based on a more conservative "K-65 only" formulation in the unanticipated absence of Silo 3 material. Drawing SK-F-04076 (Appendix A) provides a basic process flow diagram for the hydraulic retrieval system.

### 2.1.2 System Description

The Hydraulic Retrieval system is comprised of the following components as shown in Drawing No. SK-M-04095 (Appendix A). Drawing No. SK-N-04220 (Appendix A) provides a piping and instrumentation diagram for the hydraulic retrieval system described below.

Slurry Pump Assembly

The basic operation of the slurry pump assembly is as follows: A submerged high pressure water jet (pump jet), with remotely operated flow control, undercuts the residue, repulps it, and transforms it into a slurry. The slurry flows by gravity to the suction of an electrically driven submersible slurry pump which discharges the slurry through a hose. A sink ring is provided for penetration into the residue and to create a cavity for the pump suction. An eductor ring is used to prime the slurry pump, break up large pieces of residue, and keep the pump suction clear of debris. The pump will be modified to include a suction screen to help protect the pump from debris. The slurry pump is designed to handle 140 gpm of slurry at 20 percent solids by weight at a total dynamic head of 70 feet when supplemented by a variable speed drive. The Marconaflo "dyna-jet" is shown in Drawing No. 9-69167, located in Appendix B-1.

Sluicing Jets

A single point, remotely operated, sluicing water jet will be mounted from the superstructure over two of the outer manways (NW and SE). The jets will be able to rotate a full 360 degrees in a horizontal plane. At the same time the jets can move from vertical position facing straight down to approximately 153 degrees from the vertical (27 degrees from straight upward. The jets operate with a variable flow rate (pressure) and are capable of reaching almost any point within the silos. The jets can be stopped at any position. The above mentioned movements have adjustable speed and can be fully automatic or manually controlled from the FRVP control room using in silo cameras. Limits can be placed on sluicing jet movement to preclude inadvertent impingent of the spray on the silo walls. A catalog cut for a typical sluicing jet is located in Appendix B-2.

Slurry Transfer and Recycle Water Lines

The slurry piping will run horizontally along the east side of the superstructure beneath the shielding and will travel down vertically on the east tower until they get to the pipe rack (see B-18). The slurry transfer and recycle return lines are double-walled to provide secondary containment of the radioactive residues.

Monorail System

Residue retrieval equipment is moved and positioned within the ER through the use of a 10-ton monorail system. The monorail is mounted in the upper level of the ER from the overhead and runs along the center axis over the silo opening and directly above the maintenance carriage tracks. Three trolleys are located on the monorail and are used to lift the slurry pump and Houdini TMADS from the maintenance carriage and position them over the silo opening for deployment. Two of the trolleys are combined in a single unit and are used to lift and position the TMADS. When the TMADS is lifted into position, it is held firmly in place to counteract moment loads. The third trolley is used to lift and position the slurry pump. The trolleys are locally or remotely operated, will include mechanical stops on the monorail ends, and can be locked over the center manway in their deployment positions to help ensure accurate positioning. A vendor drawing for a typical motorized trolley is provided at Appendix B-3.

Camera System

A closed circuit video system provides for monitoring of both equipment and personnel operations in the ER and equipment operations within the silo headspace. Two color cameras are mounted in opposite corners of the lower level of the ER while two additional cameras are provided in two of the outer manways of the silo dome. The cameras are connected to the central control room in the FRVP. The cameras are provided with a pan and tilt mechanism operated by a manipulator from the control room. The cameras mounted in the two silo dome outer manways (opposing) will be provided with lights and will be mounted as an integral unit to facilitate changeout operations. These cameras will share the manway with an NRTS inlet or outlet nozzle. The cameras will be radiation tolerant to help limit the need for camera changeout due to radiation exposure. A sketch of a typical manway-mounted camera system is shown in Appendix B-4.

Jib Crane

A small jib crane will be mounted in the ER near the silo opening. The jib crane will have an electric hoist and a bucket to allow retrieval of multiple discrete items from the silo in conjunction with the Houdini System. The jib crane will swing out of the way when not in use.

### 2.1.3 System Utilization

Installation

The slurry pump, packaged in a transportation/containment box, is lifted onto the superstructure using the east tower hoist. It is placed onto the maintenance carriage and rolled into the ER through the vestibule. The pump is lifted out of its transportation container and off the carriage using the monorail hoist and the tilting hoist. The pump is centered over the silo opening and the maintenance carriage is then removed from the ER. These actions are manually assisted. A sketch of the transportation container is provided in Appendix B-5.

Slurry and recycle water hoses are connected to the slurry pump along with the electrical power cables. The silo containment insert provides an interface between the superstructure mounted slurry/recycle water pipes, the slurry pump's flexible hoses, and the electrical power cable (see Appendix B-12).

After the hose/cable is connected and properly managed, the slurry pump can be remotely lowered into the silo through the containment insert as the silo doors are subsequently shut. The pump passes through the flexible interior seal of the containment insert by deflecting the seal's flexible strips and is lowered into position in the silo.

The two remotely operated unsubmerged sluicing jets are hard mounted on the lower supports of the superstructure in custom containment enclosures which are rigged into place via a mobile crane and suspended in the manway using a bag-in/bag-out procedure (the manway covers are stored on the superstructure for future use). The enclosures are then hard mounted to the support structure. A flexible joint attached to the bottom of the jet enclosure is used to connect the jet enclosures to the manway so they can seal the silo manway without putting load onto the manway itself. Utility connections are then made and movements of the sluicing jets are tested for clearance. A sketch of the sluicing jet in its enclosure is located at Appendix B-6.

Operations

At the beginning of operation, the integral sink rings and pump jet will slurry the material in the immediate vicinity of the pump until a slurry pool is created from which the pump can start its suction. As the suction progresses, the sluicing jets, mounted in the silo dome manways, are directed at areas adjacent to the pump to create and direct slurry flow toward the pump suction. The sluicing jets will be rotated as needed to continue to direct slurry from the outer portions of the silo to the pump while enlarging the slurry pocket. This should be done with care to avoid creating a wall of residue that could collapse on the pump. The pump is lowered only as needed to maintain suction. Operation of the sluicing jets and the slurry pump will be controlled to limit the depth of the slurry pool. The slurry pool will be pumped down prior to pump shutdown.

If deemed necessary, the sluicing jets can be used to perform gross decontamination and removal of excess residue from equipment in the silo headspace prior to withdrawal of the equipment into the silo insert.

Maintenance

If minor maintenance to the slurry pump is required, it will be performed in the ER. Major maintenance will require removal of the pump from the superstructure. Prior to performing maintenance, a determination of the degree of maintenance required and the potential resultant radiation dose to workers will determine the need to remove the pump from the superstructure. Removal of the slurry pump from the silo requires that the Houdini vehicle be extracted into the TMADS and the PDCU be removed from the superstructure. Slurry pump removal would be performed as follows:

1) Secure hydraulic retrieval operations, including backflushing of lines and slurry pump.

2) Center the pump under the silo doors and raise it into the containment insert chamber.

3) Spray down pump as it rises into the containment insert chamber and allow excess moisture to drip off.

4) Line the floor of ER with temporary plastic liner in areas where the pump will hang and be positioned for placement in the containment box.

5) Shutdown ER ventilation. The NRTS will remain in operation to maintain airflow from the ER to the silo. Remotely open the silo doors, raise the pump into the ER, and close the silo doors.

6) Following restoration of the ER ventilation, personnel will enter ER and perform maintenance or inspect the pump. If it is necessary to remove the pump from the ER/superstructure, the pump

hoses and power cable will be disconnected from the pump and be attached to a safety device to prevent them from falling back into the silo.

7) The pump is then rigged into its transport container on the maintenance carriage. Otherwise it would be moved via monorail from over the silo doors to allow personnel access for maintenance.

8) Once the pump is sealed in its transport case, it is moved to the vestibule where the container is surveyed for external contamination prior to removal from the superstructure.

9) Following maintenance or pump removal, the plastic liners are removed and a radiological survey is performed in the ER.

If maintenance is required on the sluicing jets, the entire jet enclosure will be removed from the manway and superstructure using a glovebag arrangement. The manway will be sealed with a cover plate (blank flange) and the jet enclosure bagged and rigged off the support platform using a remote crane.

Removal/D&D

Final removal of the slurry pump and sluicing jets will be similar to the procedures used for maintenance. The pump will be removed prior to Decontamination and Decommissioning (D&D) of the silo. The sluicing jet may be used for D&D of the silos and can be reprogrammed to impinge on the silo walls in a systematic pattern for decontamination.

## 2.2 Houdini

### 2.2.1 Functions Provided

Discrete Object Management

During bulk retrieval the Houdini vehicle may be lowered into the silo headspace to assist in handling discrete objects which may interfere with the hydraulic pump. Due to the slurry consistency during bulk retrieval, the Houdini vehicle will not likely be able to operate on the residue surface and therefore would be operated while suspended from its tether. Houdini will either retrieve objects in hand, place objects in a tram bucket deployed from the ER, or transfer the object away from the pump.

Heel Removal

Following bulk retrieval, the Houdini vehicle may be deployed into Silos 1 and 2 to remove residue and other discrete objects which were inaccessible or unretrievable by the bulk retrieval system. Either the main slurry pump or the small sluicing tool provided with the Houdini can be used in conjunction with Houdini to transfer the heel out of the silo.

Decontamination and Decommissioning

The Houdini system will assist in the inspection and final D&D of the silos after the completion of retrieval operations. It can be used in conjunction with the sluicing jets by using its squeegee to help transfer standing wash water to the pump. It can use its arm mounted camera for close-up inspection of the concrete condition. It might also be tooled to take swipe samples of the concrete for decontamination effectiveness evaluation.

### 2.2.2 System Description

The Houdini system is comprised of five major subsystems as shown in RedZone Drawing 9411-0000 (Appendix B-7) and described below.

Houdini Vehicle

The Houdini vehicle is a hydraulically powered, track driven, folding frame mobile robot. Its basic form is similar to a small bulldozer as shown in RedZone Drawing 9411-0121 (Appendix B-8). The vehicle is equipped with a height adjustable plow blade for moving material, and a dexterous manipulator arm which can deploy a variety of tooling. The vehicle is provided with two color cameras, one mounted on the manipulator and the other on the chassis. A microphone is mounted on the manipulator next to the camera. The vehicle folds as a parallelogram to fit through an opening as small as 24 inches in diameter during deployment and retrieval. When unfolded, the vehicle (including its manipulator) is approximately 40 inches wide, 102 inches long, and 15 inches high. The vehicle is deployed and controlled through a tether which provides hydraulic power, electric power, control and data transfer, and physical retrieval.

Tether Management and Deployment System (TMADS)

The TMADS is used to remotely deploy and store the vehicle tether and to store the vehicle when not in use. The TMADS consists of 150 feet of tether and a tether reel which is remotely operated to pay out or retrieve the tether. The TMADS contains a docking bay for the vehicle and is used as a transport and storage container for the vehicle and its associated tooling and parts. The TMADS is enclosed in a supporting frame which is covered to provide shielding and containment during transportation and storage. The TMADS frame has multiple lifting points which can be used for rigging and mounting for deployment. The vehicle deploys vertically downward through the docking bay door located in the bottom of the TMADS. The TMADS assembly is shown in RedZone Drawing 9411-0105 (Appendix B-9).

Power Distribution and Control Unit (PDCU)

The PDCU serves as an interface between the vehicle and the operator control console. The PDCU consists of an electrical enclosure and a hydraulic power supply mounted on a common base. The PDCU base has pockets for forklift transfer and eye bolts for crane transfer.

The electrical enclosure accepts 480 volt, three phase, 60 hertz site power and distributes power to all other Houdini system components. The electrical enclosure is provided with a main power disconnect (breaker) which is tripped automatically or remotely. The electrical enclosure is environmentally sealed and has integral heating and air conditioning systems.

The hydraulic power supply consists of a skid mounted pump, motor, and reservoir, and provides hydraulic power for the Houdini vehicle and the TMADS tether reel. The hydraulic system has an integral cooling and filtration loop, and a resistive heating element. The PDCU assembly is shown in RedZone Drawing 9411-0080 (Appendix B-10).

Control Center

The Houdini System is operated from a remote control console housed in a standard office trailer. The trailer is provided with a roof mounted Heating, Ventilation, and Air Conditioning system and tie downs to secure it in high winds. The trailer can be towed by a pick-up truck and will require 120 volt site power during set up and operation for auxiliary loads. The Control Console is located inside the trailer and includes joysticks, switches, an emergency stop button, a master manipulator, and four video monitors necessary for normal operation and control of the Houdini system.

Suitcase Controller

The suitcase controller is a simplified portable control console which can be used to by-pass the operator control console in the control center. The suitcase controller provides an auxiliary facility for on-site debugging, local operations, and system checkout, and can be used as a back-up control center in the event of temporary loss of the primary controller. The suitcase controller is attached to the PDCU by cable and contains a single monitor and control panel for direct open loop control of the Houdini actuators and camera system.

## 2.2.3 System Utilization

Installation/Removal

The Houdini system will be manually installed and removed from the Silo 1 and 2 superstructures after construction of the superstructure and retrieval system. Houdini may be installed and removed (including vehicle deployment and retrieval) without interrupting bulk hydraulic retrieval operations. Since the Houdini system will service all three silos, it will be relocated as required during and following retrieval operations.

The Houdini system is manually installed on the superstructure. Both the TMADS and PDCU units will be lifted onto the superstructure span using the tower hoist and maintenance carriage. A flatbed truck will be used to transport the system between silos. TMADS is rigged in place over the enlarged center dome manway using the ER monorail and tilt hoist. The PDCU will be installed directly on the maintenance carriage outside the ER and vestibule on the superstructure. Cables are run through superstructure cable trays from the TMADS to the PDCU and from the PDCU down the superstructure to the control console in the control trailer. All electrical and hydraulic connections to the PDCU will have quick disconnects to minimize set-up and take-down time. In addition, permanent sets of cables and hoses will be installed in the ER to further facilitate connection of the TMADS to the PDCU during set up and take down.

The Houdini system is readily transferable between silos. At the completion of its use in a specific silo, the vehicle will be gross decontaminated using the silo insert spray rings in a manner similar as that used for the slurry pump. A potable water washdown connection is provided in the ER if additional manual wash of the vehicle is required to remove excess residue. The vehicle will be stowed and sealed in the TMADS module to provide shielding and containment during transport. The TMADS box will be swiped for radiological contamination prior to removal from the ER and will be further decontaminated or packaged if required prior to removal from the superstructure.

Operations

The Houdini vehicle is deployed remotely from the TMADS through its bottom door. The silo doors are opened momentarily to allow entry of the vehicle into the silo headspace and then closed to maintain ventilation and containment requirements. Deployment of the vehicle is monitored remotely using the ER mounted cameras. The vehicle will operate from the hanging position using its manipulator as possible or it can be set down on the residue surface or floor of the silo after the residue has been sufficiently dewatered for more extensive use.

Maintenance

Minor maintenance and system checks will be performed on the vehicle in its stowed position in the TMADS within the ER. Access to the vehicle is achieved by removing the appropriate TMADS access panel. Any major maintenance will require that the TMADS and PDCU be removed from the superstructure to reduce radiological exposure to the maintenance personnel.

## 2.3 Silo Dome Segment Removal System

### 2.3.1 Functions Provided

Silo Access

Provide a means of accessing the silo to deploy equipment (slurry pump, Houdini) into and out of the silo from the ER.

Containment

Prevent the release of radiological contaminants from the silo to the environment from the interface between the silo and ER.

### 2.3.2 System Description

This concept for dome cutting and segment removal was previously developed under a separate project and will be modified during detailed design for use on Silos 1 and 2. Details for illustration of the concepts discussed below are provided in Appendix B-11.

Ultra High Pressure Water Cutting Device

The cutting device utilizes water (approximately 1.5 gpm) under high pressure (36,000 to 40,000 psi) focused to create a fine jet to cut an approximate 6-foot diameter segment from the steel reinforced concrete silo dome. The cutting device is supported by a circular jig which is attached to the underside of the ER. The cutting device is operated from a remote station on the superstructure and travels around the circular jig to complete the segment cut. During cutting operations, the NRTS is in operation to develop a negative pressure in the silo headspace which will tend to pull the water and concrete particles into the silo headspace. This operation will be performed within the outer dome seal to help maintain containment. Heavy equipment, such as the compressor and potable water tank, will be located on the ground.

The design concept provides flexibility for the cutting equipment and cutting operation such that the procurement specification will be performance oriented with limited technical direction. This approach allows prospective subcontractors to utilize their experience in designing the particulars of the cutting configuration, setup, and rig. The specification will provide detailed information on the ER design and existing silo domes to allow prospective subcontractors to estimate and bid their work accurately. This operation will first be demonstrated on Silo 4 prior to performance on Silos 1 and 2.

Outer Dome Seal

The outer dome seal is installed between the underside of the ER and the silo dome surface. This seal provides containment during dome cutting and remains in place following installation of the silo containment insert (see Section 2.4). The outer dome seal is comprised of a sheet metal enclosure suspended from the underside of the superstructure and an extruded rubber shape which is pop riveted and cemented between the bottom of the sheet metal enclosure and the top of the surface of the dome. The outer dome seal will be installed in a square configuration located within the 24-foot peripheral circular dome support cables.

### 2.3.3 Operation

Installation

The following is a chronological sequence of events which provide for enlargement of the central silo manway and installation of the containment insert into the enlarged opening. This sequence is identical for Silos 1 and 2.

Activities required prior to cutting:

1) Install and operate the NRTS to lower the radon concentration in the silo headspace and reduce potential radiological exposure to personnel working above the silo domes. The NRTS will remain in operation throughout the cutting process, removal of dome segment, and installation of silo insert. Additionally, prior to this operation, steps should be taken to reseal any cracks in the bentonite cover to further reduce radon emanations to the headspace as deemed necessary.

2) Remove the 30-foot diameter, structural steel frame and plywood silo dome cover, which presently covers the center of the silo dome. The dome cover will be removed using a mobile crane prior to superstructure erection.

3) Erect the silo superstructure and ER. The cutting jig for the high pressure cutting jet will be pre-installed on the underside of the ER (less the cutting device). The superstructure equipment (i.e., HVAC, hoists, maintenance carriage) will need to be fully operational.

Activities directly pertinent to the conceptual design of the ER/silo seal and dome segment cutting evolution:

1) Install dome support cables on the silo dome via eyebolts in a 24-foot diameter circle and attach them to the underside of the silo superstructure. The support wires will be slack and are installed as a contingency if part of the dome fails during remediation. The dome supports will limit the potential for total collapse of the inner 30-foot section of the silo dome.

2) Install the outer dome seal between the ER and the silo dome. This seal provides containment against the release of contaminants during dome cutting operations.

3) Install eye bolts in the segment of the dome to be removed. These eye bolts are attached to the slurry pump monorail trolley and will be used to support the segment during cutting and raise it from the dome into the ER once it has been cut.

4) Install the ultra high pressure water cutting device. Plastic lining will be placed on the floor to prevent the potential spread of contamination during subsequent steps.

5) Move the containment insert into the ER and hang it on the TMADS monorail trolleys on the east side of the ER.

6) Cut the dome segment by remotely engaging and controlling the high pressure cutting device from outside the ER. Upon completing the cut and removing the cutting equipment as necessary, remotely raise the segment into the ER and move it to the west end of the ER. Remotely position and lower the containment insert into the dome opening. The ER and dome-mounted cameras are used to monitor this evolution. The containment insert doors remain shut. Personnel in full PPEs and breathing apparatus will be standing by in the vestibule to supplement remote operations as necessary.

7) Personnel in full PPEs and breathing devices enter the ER. The dome segment is bagged (wrapped) in plastic. The containment insert is bolted in place and its inflatable seal is pressurized remotely from the ER. The bagged dome segment is placed onto the maintenance carriage and moved to the vestibule for survey and removal from the superstructure via the east tower hoist.

8) The inflatable seal is inspected to verify adequate contact with the silo dome. If cracks or openings exist around the perimeter of the seal, the seal pressure may be adjusted and the cracks and openings may be sealed with filler or grout to provide an adequate seal.

## 2.4 Silo Containment Insert

### 2.4.1 Functions Provided

Silo Access

Provide a means of accessing the silo throug insert to deploy tethered equipment (slurry pump, Houdini) into and out of the silo from the ER.

Directional Airflow

Maintain a high velocity airflow from the ER into the silo, through the insert, at the interior seal to limit the release of either particulate or gaseous radioactivity from the silo into the ER during transfer of equipment into and out of the silo.

Containment

In conjunction with the ER and the outer seal, prevents the release of radiological contaminants from the silo to the environment.

Washdown

Provide a means to remove gross external residue from discrete objects and equipment being removed from the silo into the ER.

### 2.4.2 System Description

The silo containment insert satisfies the functions listed in Subsection 2.4.1. Generally, the containment insert is a cylindrical, slightly conical, shaped stainless steel tube approximately 11 feet long which provides a passage from the ER to the silo. The major features of the containment insert are shown in the Silo Containment Insert Sketch located in Appendix B-12 and described below.

Inflatable Seal

An inflatable rubber seal is located around the outside of the silo containment insert and when inflated provides a seal between the outside of the insert and the inside edge of the enlarged dome opening to prevent the in-leakage of air while operating the NRTS. Details of the inflatable seal are located in Appendix B-13.

Interior Insert Seal

The bottom of the containment insert contains an interior flexible seal to reduce airflow between the ER and silo headspace. This reduction in airflow is necessary to limit the overall required capacity of the NRTS. The seal is comprised of inwardly pointing, long triangular pieces of semi-rigid plastic attached around the inner perimeter of the containment insert. The strips normally limit airflow from the ER into the silo, but are readily parted by equipment being hoisted into or out of the silo.

Hose Guard

A metal protective sleeve runs vertically along the inside of the insert. The guard houses and protects the slurry and recycle water hoses and electrical cable from damage by equipment rigged through the insert. It also allows for easy changeout or repair of hoses.

Silo Doors

Two steel doors further isolate the ER from the silo to help ensure a directed airflow. The silo doors conform to the slurry pump cables and Houdini tether to allow their continued deployment with the doors closed. The doors will have lip around the outside perimeter such that wash down water which might drip from suspended equipment is contained and diverted back to the silo through the hose slots and center opening. The doors are made of carbon steel and swing inward into the ER. They are operated remotely by hoists. Mechanical stops will prevent the doors from opening beyond vertical. The steel plate construction of the doors are designed to provide radiation shielding from the silo.

Containment Insert Spray Rings

The containment insert contains three stages of spray rings which inject pressurized water into the containment insert annulus to wash down equipment and remove excess residue prior to removing the equipment from the silo. Spray water will be recycle water from the FRVP which is normally supplied to the sluicing jets and the slurry pump.

### 2.4.3 System Utilization

Installation

The silo containment insert is installed between the silo dome and the ER after the dome segment has been cut and removed from the dome. During this evolution the NRTS is operational and the ER ventilation system is stopped. Prior to cutting and removing the dome segment, the silo containment insert is rigged into position in the ER and suspended from the monorail using the TMADS trolleys. The containment insert remains out of the way to the east end of the ER. The following steps are provided for the installation.

1) After the cut dome segment has been lifted and removed from the dome using the slurry pump trolley, the TMADS trolleys are operated remotely to move the containment insert over the dome opening and lower it into position. Cameras in the ER will be used to monitor the operation and aid in positioning.

2) The ER ventilation system is started. Personnel enter the ER, verify the position of the containment insert, bolt the containment insert in place, and pressurize the inflatable seal.

3) Remove dome segment from the ER as discussed in Subsection 2.4.2.

Operations

During normal bulk retrieval operations the silo doors will be shut. When equipment is removed from the silo, it will involve the following sequence of events (for discussion of airflow see Subsection 2.5).

1) Equipment to be removed from the silo is positioned so that it is hanging in the center of the silo containment insert and then hoisted slowly into the containment insert to a point just below the silo doors. An indicator attached to the hoist cable will be visible via the ER cameras when the equipment is raised to just below the silo doors. As the equipment rises above the containment insert interior seal, the containment insert spray rings wash down the equipment. Silo mounted cameras allow monitoring of the equipment as it enters the insert from the silo.

2) Following washdown, the equipment remains in place for a time to allow water and residue to drip from the equipment into the silo through the interior seal.

3) The ER ventilation is stopped. Note: during this time the ER will continue to be maintained at a negative pressure with respect to atmosphere by the NRTS. The silo doors are opened remotely and the equipment is hoisted into the ER directly over the silo doors. The doors are then shut remotely.

4) After the ER ventilation flow has been re-established, personnel can enter the ER to monitor and inspect the equipment or remove it from the ER as applicable.

Maintenance

There is no maintenance associated with the containment insert other than the periodic lubrication of the door assembly. Pressure in the outer seal is monitored on a regular basis to insure the integrity of the

The air cleaning devices will be factory assembled and tested bag-in/bag-out High-Efficiency Particulate Air (HEPA) filter housings for outdoor installation. Each assembly unit will be supplied with a prefilter section, and a HEPA filter section. Differential pressure gauges will be installed for each prefilter and HEPA filter. An alarm will be provided for high and low differential pressure across prefilters and HEPA filters. A typical HEPA filter unit is shown in B-14. The ER ventilation HEPA filter unit will require a 2 x 3 configuration.

Exhaust Fan

The exhaust fan is used to maintain a design volume flow rate from the ER and will be interlocked with a motorized air inlet damper and the NRTS to maintain a negative pressure in the ER and to ensure that airflow is from the ER to the silo. The exhaust fan will be centrifugal with a motor and belt drive installed on a common base with vibration isolators. The exhaust fan will be installed on a concrete pad. Variable inlet vanes will be provided to compensate for dust loading on air cleaning devices. A typical exhaust fan is presented in Appendix B-15.

Stack

The stack is for discharging exhaust air to the atmosphere. The stack height will be 12 feet above the ER roof and structurally designed to withstand the maximum predicted wind load. Isokinetic sampling will be installed in the stack to provide emission monitoring. The stack would also service the NRTS or the exhaust could be piped directly to the FRVP off-gas stack to eliminate the need for multiple stacks.

Air Inlet Damper

A motor-operated air inlet damper located in the outer vestibule wall provides a controlled influx of outside air through the vestibule and into the ER while maintaining the ER at a negative pressure. The air inlet damper will be multi-blade, parallel, with an electrical actuator. A typical inlet damper is shown in Appendix B-16.

### 2.5.3 System Utilization

Installation

The air cleaning devices, fan, and stack will be installed on the ground next to the superstructure. The air inlet damper will be mounted on the ER wall at the time of ER assembly. Ventilation ductwork will be installed in the superstructure prior to installation of the superstructure over the silo.

Operations

The NRTS fan will run continuously during the retrieval operations to maintain negative pressure in the silos. When the ER is occupied or when temperatures approach 100 degrees F, the ER ventilation system will run to provide ventilation and cool the room, otherwise it is not required and can be shut down. The ER ventilation system will not run unless the NRTS is operating to ensure proper direction of airflow.

Airflow in the ER will be as follows: outside air will enter through the air inlet damper in the vestibule, move across the vestibule, enter the ER through a manual damper in the vestibule/ER wall, and will then be exhausted from the ER through air cleaning devices by the ER exhaust blower into a monitored exhaust stack. This arrangement provides for directional airflow from the atmosphere through the vestibule and ER. Transfer of air between the silo headspace and the ER will inherently be in the direction towards the headspace based on the NRTS maintaining the lower pressure in the silo headspace relative to the ER.

The ER ventilation system is integrated with the NRTS. During all stages of operation and maintenance, pressure in the silos will be less than ER and atmospheric pressure. This requires the NRTS fans to always be started prior to operation of the ER exhaust fan. The ER exhaust fan will be interlocked with the vestibule air motorized inlet damper. The differential pressure detector will position the air inlet damper to control the airflow from outside to maintain a preset negative pressure in the ER, when the ER exhaust fan is energized; otherwise the inlet damper will be closed. The ER ventilation system will be interlocked to de-energize the ER exhaust fan if ER pressure drops below (approaches) the silo pressure.

Redundant air cleaning devices (HEPA filers) will be provided for the ER exhaust to facilitate filter changeout. Low and high differential pressure alarms will be provided for prefilters and HEPA filters to indicate a leak in the filters or time to change filters.

Isokinetic stack samples will determine and record the total quantity and quality of air discharged to the atmosphere and identify the quantity and concentration of any radionuclide emissions.

Maintenance

Most equipment requiring periodic maintenance will be located on the ground. Filter replacement will be bag-in/bag-out operation. The stack sampling station will require a well-lit access platform for inspections and/or service. The motorized damper located on the vestibule wall will be oriented such that maintenance can be performed outside of the vestibule.

Removal/D&D

The ER ventilation system will remain in operation throughout D&D operations until containment of the ER and ventilation is no longer required. At the completion of their use, they will be decontaminated and decommissioned.

## 2.6 New Radon Treatment System

The New Radon Treatment System will be the subject of a separate design effort and will not be included in the title design for Residue Retrieval Systems. It is included in this conceptual design to fully develop integration issues associated with design of the superstructure and residue retrieval systems.

### 2.6.1 Functions Provided

Control of Radon

Reduce and control the radon concentration in the headspace of Silos 1 and 2 (K-65 Silos) to limit personnel exposure levels in the ER over each silo.

Maintain Negative Pressure

Maintain a negative pressure in the headspace of the K-65 Silos throughout residue retrieval operations to limit ER contamination and provide a controlled release of radon to the atmosphere. The pressure in the silo headspace will be maintained negative with respect to the ER to direct airflow from the ER into the silo.

### 2.6.2 System Description

The NRTS will service the two K-65 Silos to allow independent residue retrieval operations from each silo. The major components of the NRTS are shown on Sketch SK-F-04075, Appendix A, and are described below.

Condenser

The condenser is used to remove water vapor from the radon-laden air prior to entering the carbon beds. The efficiency of the carbon beds and HEPA filters is increased as the water content of the air is reduced. Condensate from the system will be collected and pumped to the FRVP. The condenser will be indirectly cooled by a local closed-loop refrigeration system to increase the efficiency of the carbon beds.

Desiccant System

The desiccant system is used to remove any remaining water vapor from the air, following the condenser, to further increase the radon removal efficiency of the carbon beds. The system will utilize a consumable desiccant. The liquid generated will be collected and transferred to the FRVP from the condensate tank.

Carbon Beds

The carbon beds are used to remove (adsorb) radon from the air in the headspace of Silos 1 and 2 (K-65 Silos). Each carbon bed will contain a quantity of activated carbon through which the radon-laden air from the silo headspace will pass. Two carbon bed systems are used and are described below.

The primary carbon beds are used to reduce the initial radon concentration in the silo headspace and to maintain the concentration at a design level. This system recycles the air from the silo through the treatment equipment and returns it to the silo headspace.

Bleed carbon beds are used to further reduce the radon concentration in the bleed air stream to a design level prior to discharge to the environment. The bleed stream is withdrawn from the recycle stream (following the recycle fan) to maintain the desired negative pressure in the silo headspace.

Recycle Exhaust Fan

The recycle fan will be used to maintain a design airflow from the silo headspace through the condenser, desiccant, primary carbon beds and return it to the silo headspace.

Bleed Exhaust Fan

The bleed exhaust fan is used to maintain a negative pressure in the silo headspace. Flow through the fan will be controlled to maintain the desired negative pressure in the silo headspace.

Air Cleaning Devices

A bag-in/bag-out HEPA filter system will be used to remove any particulates from the bleed air stream prior to discharge to the atmosphere.

### 2.6.3 System Utilization

Installation

The equipment for the NRTS will be installed on the ground near the silos to minimize duct length.

Portions of the ductwork to and from each silo will be supported by the new superstructures to be erected over each K-65 Silo. These sections of duct can be placed on the superstructure prior to erection over each silo. The final duct connections to the silos and to the NRTS equipment will be made after installation of the superstructure.

The existing Radon Treatment System (RTS) can be operated to lower exposure dose rates for workers if necessary prior to erection of the superstructures and prior to connection of the NRTS ductwork to the silo manways.

Following final connection of the new ductwork, the NRTS can be started and the existing RTS duct can be disconnected from the silo dome and capped. The existing RTS building will be left in place until D&D of the silos. The existing RTS ductwork will be removed as required during berm removal.

During berm removal, depending on the condition of the silo walls, the exterior walls of each K-65 Silo may be sealed to help limit air infiltration through the silo walls, thus maintaining the effectiveness of the NRTS (see Subsection 2.11.3).

<u>Operation</u>

The NRTS will be remotely operated and controlled from the FRVP. The NRTS will be started prior to the penetration through the silo dome from the ER. Following the penetration of the silo dome, the system will be operated as necessary throughout the project. Requirements for continuous operation of NRTS will be addressed/developed by the NRTS design.

<u>Maintenance</u>

All equipment will be located on the ground which will aid in access for maintenance. The carbon beds and desiccant system will be located inside a shielded portion of the NRTS structure. This structure will be compartmentalized to provide shielding from other areas while maintaining equipment. Operational spares (HEPA filters) will be provided as needed to limit operational downtime for maintenance and filter changeout.

Periodic recharge of the desiccant system will be required, however, this may be possible from outside the shielded structure. Recharge capability of the carbon beds will also be provided. The use of the condenser system will limit the load on the desiccant and thus extend time between recharges.

The duct/manway/silo camera interface will be such that camera changeout will not required shutdown of the NRTS.

D&D

Following shutdown of the NRTS system, the system must be left idle to allow sufficient decay of residual radioactivity in the equipment. After the decay period, the equipment and structure can be dismantled and disposed as low-level waste material. The existing RTS system (ductwork and building containing desiccant and carbon beds) can also be removed at this time.

## 2.7 Operational Control System

### 2.7.1 Functions Provided

Monitor Operations - Provide visual feedback on the activities of equipment and personnel in the ER during operations and maintenance.

Monitor Retrieval System - Provide remote monitoring of key superstructure mounted, retrieval system component parameters to ensure the safe operation of the retrieval system while minimizing the need for local manual inspections.

Remote Operability - Allow remote operation and control of primary retrieval functions necessary to minimize manual operations in the ER or on the superstructure for routine operation. This will be accomplished by utilizing a distributed control system (DCS). The system is conceptually defined on sketch number SK-N-04295, Control System Architecture Drawing - Sheet 1 (Appendix A).

### 2.7.2 System Description

Remote Operations - Table 2-1 lists the functions on each piece of major equipment which can be operated remotely. Dedicated communications between FRVP control room and the Houdini command trailer will be provided to allow coordination. Note that the Houdini control system can be readily incorporated into the FRVP control room to allow for a centralized control point. In addition to remote operations, the capability for local override and lockout of equipment will be provided for local control as necessary.

Remote Monitoring

Process monitoring will be provided for both remote and local monitoring including, but not limited to, line pressure, room pressure, flow, density, and area radiation monitoring. Specific parameters will be determined during Title I/II design consistent with control philosophy.

## 2.8 Equipment Room

### 2.8.1 Functions Provided

Provide Containment

The ER will provide radiological containment during residue retrieval system operations. The vestibule will provide a means for workers and equipment to enter and exit the ER without spreading contamination.

Shield Personnel

The ER will provide shielding to reduce personnel radiation exposure consistent with As Low As Reasonably Achievable (ALARA) requirements.

Table 2-1 - Silo 1 and 2 Remotely Operated Functions

| Equipment | Function | Where Controlled |
|---|---|---|
| Slurry Pump | On/Off Slurry Pump<br>Pump Backflush<br>On/Off Water Jet<br>Rotate Water Jet<br>On/Off Sink Ring<br>On/Off Eductor Ring | FRVP Control |
| Slurry Pump Trolley | Raise/Lower Pump<br>Laterally position trolley | FRVP Control |
| Houdini TMADS | Open/Close Door<br>Raise/Lower Tether | Houdini Control |
| Houdini Vehicle | All Vehicle Operations | Houdini Control |
| Houdini PDCU | All System Monitors and Controls<br>Emergency Stop | Houdini Control |
| Houdini TMADS Trolleys | Raise/Lower TMADS<br>Laterally position trolley | FRVP Control |
| Silo Door Hoists | Open/Close Doors (individually) | FRVP Control |

Table 2-1 (Continued) - Silo 1 and 2 Remotely Operated Functions

| Equipment | Function | Where Controlled |
|---|---|---|
| Silo/ER Containment insert | On/Off Washdown Spray<br>Variable Flow | FRVP Control |
| Sluicing Jets | On/Off Flow<br>Variable Flowrate<br>Rotate (pan)<br>Tilt | FRVP Control |
| ER Ventilation Exhaust Fan | On/Off exhaust fan | FRVP Control |
| ER and Silo Cameras | Pan, Tilt, and Zoom | FRVP Control |

Weather Protection

As necessary, the ER will protect the residue retrieval and support equipment from the elements. It will also provide a sheltered means to inspect, maintain, maneuver and transport equipment within the ER as needed to support operations and maintenance.

### 2.8.2 System Description

Equipment Room

Residue retrieval equipment is housed and deployed from an ER located on the silo superstructure and centered over the enlarged center silo manway. The ER layout is shown in Drawings SK-M-04094, SK-M-04294, and SK-M-04095 (Appendix A). The ER is approximately 16 feet wide by 30 feet long by 30 feet tall. A large equipment door on the east wall provides ER access for personnel, equipment, and the maintenance carriage. The floor includes steel shielding to limit the whole body exposure in the ER.

A platform in the upper level of the ER provides access to the monorail trolleys, hoists, and other equipment mounted in the upper portion of the ER. The platform is accessed by two internal ladders. Two small 3-ton hoists are mounted below the floor of the upper platform at the east and west ends of the ER and are used to raise and lower the silo containment insert doors and to assist in rotating the slurry pump/TMADS as it is lifted off the maintenance carriage. These hoists are remotely operated with local override. A catalog cut for a typical 3-ton hoist is provided in Appendix B-17.

The ER ventilation system is discussed in Subsection 2.5. Other support systems included in the ER are breathing air connections, compressed air connections, 120 and 240 volt electrical receptacles, fire extinguishers, radiation and radon monitors, process water, lighting, and an intercom system for communications with the control room.

Vestibule

A vestibule is located on the silo superstructure on the east end of the ER. The vestibule is approximately 16 feet wide by 25 feet long by 15 feet tall, and is of similar construction to the ER. The vestibule serves to provide a control area for ingress and egress to the ER by personnel and equipment. A large equipment door (similar to the one which passes into the ER) is provided for transporting equipment into and out of the vestibule onto the superstructure. A personnel door on the south wall of the vestibule allows an alternate egress to the superstructure. A door on the north wall allows access to the platform for the northeast outer manway platform. The maintenance carriage tracks pass through the vestibule into the ER along the centerline of the superstructure. The vestibule provides a radiological buffer area for personnel to remove potentially contaminated PPEs and survey and decontaminate equipment prior to exiting the superstructure. The floor includes steel shielding to limit the whole body exposure in the vestibule. Additional local shielding is provided in the vestibule at the personnel change area. The vestibule is provided with lighting, 120 volt receptacles, fire extinguishers, breathing air, and an intercom as well as radiation and radon monitors.

### 2.8.3 System Utilization

Installation

The ER and vestibule are constructed as four separate modules (three for ER, one for vestibule) which are shipped individually to the site for assembly. The modules will be lifted and installed onto the assembled superstructure truss one at a time while the truss sits on the ground in the superstructure laydown area (See Drawing No. SK-G-04010, Appendix A). The roofing and siding will be installed on the ER/vestibule after the individual modules are connected. The monorail, hoists, and cameras and other control and auxiliary equipment will then be installed in the assembled ER/vestibule module. To reduce personnel exposure, installation and equipment testing will be performed to the maximum extent possible prior to rigging the ER/superstructure truss over the silo dome. Final sealing and testing of the ER for containment will be performed after the truss has been lifted in place.

Operation

During normal operation the ER is unmanned and the retrieval equipment (slurry pump) is operated remotely. The pump is raised and lowered remotely as the residue level in the silo is reduced as operations dictate. The silo cameras and in-line density meters will be the primary tools used to determine the need to raise/lower the slurry pump.

Maintenance

Required preventative maintenance on the ER mounted equipment is limited to routine greasing of the monorail and hoists. A specific PM program will be developed for the hoists to meet the intent of the FEMP Hoisting and Rigging Manual while incorporating ALARA practices. Relamping as necessary, and standard maintenance on the monitors and camera systems will be required. Cameras, monitors, detectors, and hoists will be mounted to allow easy removal and replacement. If a component fails, it will be replaced and the failed component will be repaired in the shop, if feasible.

D&D

The ER can be used to deploy decontamination equipment during silo D&D. The interior of the ER will be coated with a strippable coating prior to the start of retrieval operations to allow for ease of decontamination when the retrieval is complete.

## 2.9 Silo Superstructure

### 2.9.1 Functions Provided

Support Retrieval Equipment

The superstructure will provide an independently supported platform over each silo dome for deployment of retrieval equipment (including the ER, vestibule, auxiliary and support equipment, and shielding) to facilitate retrieval and transfer operations under all anticipated loading conditions over the life of the retrieval operations. The superstructure will add no significant additional load to the silo domes.

Worker Access

The superstructure will provide for worker access for routine and non-routine operations, and maintenance on the superstructure installed equipment. It will allow for access and egress under both normal and emergency conditions considering potential Personal Protective Equipment requirements and other impediments.

Equipment Access

The superstructure will provide a means to lift equipment on/off the superstructure to limit the need for an overhead mobile crane.

### 2.9.2 System Description

The superstructure is a single comprehensive structure of modular design which supports the equipment enclosure, vestibule, retrieval equipment, and robotic system, and provides access to platforms for the four outer manways, supports the dome cutting rig and the shielding plate, and provides an operating platform for all retrieval operations. Plan and elevation views of the superstructure are shown in Drawings SK-S-04161 and SK-S-04162 (Appendix A).

The main superstructure truss is 232 feet long, 21 feet wide, and 12 feet tall. The truss rests on, and is bolted to, two 39-foot-tall towers (12 by 21 feet). The superstructure clears the silo dome by approximately 7 feet to allow access for workers to install dome cutting equipment and containment devices (see Subsection 2.3). The two towers are fabricated as separate modules. The west end tower includes the stairwell and the east end tower includes the ladders and monorail access platforms.

The west tower has a stairway for normal personnel access. A ladder on the east tower is provided for emergency egress. A monorail and hoist are located at the east tower to raise and lower equipment to truss height on the superstructure. Walkways and areas of normal access on the structure are provided with 0.25-inch thick steel checkered plate which supports traffic and provides minimal personnel shielding.

Four small equipment handling platforms provide access near the dome level at the four outer manways. These platforms will be used to install and adjust the water nozzles, radon treatment connections, and camera systems which will be deployed through these manways.

Slurry and recycle water lines, NRTS ductwork, ventilation ductwork, and other utility lines run in a pipe rack which hangs from the underside of the superstructure and is shielded from the walkway. Cable trays for electrical distribution and signal lines are also run beneath the superstructure. A cross section of the pipe rack showing the various pipe sizes is shown in Appendix B-18.

The superstructure will be designed to withstand all applicable loads including wind loads, snow loads, earthquake loads, equipment loads, settlement loads, dome segment loads, and piping loads as required by the project design criteria. The operating area (ER/vestibule) will be designed for 125 psf live load and other areas for 60 psf live load. The superstructure will be designed with appropriate fall protection such as swing gates, handrails, and anchors for tie-offs.

### 2.9.3 System Utilization

Installation

A modular approach will be used in the construction of the silo superstructures where all superstructure components, except for some peripherals and the end towers, will be assembled at grade and then hoisted into place for final installation as described in the next section. This approach allows the majority of the fabrication to be performed at the manufacturer's shop with limited assembly of the minimum number of major components in the field prior to erection of the final structure. The minimum number of modules is limited by the maximum size and weight of components which can be transported to the site over the road.

Once the modules arrive at the site, they will be assembled into the major superstructure components, which consist of two towers and a single span (truss) for each silo. The towers will be assembled and erected onto the superstructure foundations. The two superstructure spans will be assembled in the field and transported to the superstructure laydown area where they will be set on the temporary lift mounts. At the superstructure laydown area, final preparations are made for the span lifts including mounting of the ER on the superstructure and installation and testing of superstructure equipment, piping, and electrical runs. When erected, the silo superstructures for Silos 1 and 2 are positioned in an east-west orientation over the silos. Specific details concerning crane locations, lay down areas, and sequence of erection will be finalized following award of a rigging contract. General details for several rigging and erection approaches will be outlined in the Rigging and Assembly Concept Plan which will be prepared along with the detailed superstructure design.

The modular assembly approach will minimize the amount of on-site labor required in construction of the superstructures as well as the total radiological dose to workers from the radiation field above the silos. Substantial site preparation will be required, such as relocation of the silo fence line and utilities, modification of the stormwater management system, and preparation of the crane pads. The details of these preparations will be developed by the Fernald Environmental Restoration Management Corporation (FERMCO) based on the final rigging and assembly plan prepared by the subcontractor.

Operation

There are no particular normal operational considerations for the superstructure. The hoist located on the east end of the superstructure is used for lifting equipment and materials to span height and is locally controlled. The stairway on the west side of the superstructure provides access to the span for normal operations while the ladder is for emergency egress. The dome support cables should be maintained in a slack condition so as to not place upward load on the dome. This condition should be monitored on a regular basis to identify potential dome integrity issues.

Maintenance

Access way lights will require periodic relamping. The tower hoist will require preventive maintenance. Integrity of the dome support cables will be checked periodically.

D&D

Following bulk retrieval, heel and discrete object retrieval, the superstructure can be used to support silo D&D activities. It will remain in place through washdown of the interior silo walls and may be used for the actual silo demolition.

## 2.10 Superstructure Foundation

### 2.10.1 Functions Provided

Support Superstructure

The foundation will provide support for the silo superstructure and all loads imposed on it over the life of the project.

### 2.10.2 Description

A foundation will support the tower at each end of the superstructure. The towers are located approximately 64 feet from the silo wall and are oriented 180 degrees apart in the east-west direction across the silo. The foundations are steel reinforced concrete mats, approximately 32.5 feet by 22.5 feet and 3 feet thick. The mats will be founded approximately 2 feet above the pre-existing natural ground.

### 2.10.3 Installation

Prior to the foundation excavation, the existing silo fence will be relocated and temporary bridging may be constructed across the existing stormwater management swale for access if required. The existing RTS will be protected during the foundation excavation and will remain operational until the NRTS is in service. The excavation will extend to approximately 1 foot below the natural grade to reach firm bearing and then backfilled with 3 feet of crushed stone supporting the concrete mat. The existing silo berm will be regraded to a 2H:1V slope in the vicinity of the superstructure foundations to allow the foundation construction. The soil excavation will be accomplished with a long reach backhoe or other similar equipment. Following excavation, a 3-foot base layer of compacted stone will be added and the foundations will be poured as shown on Drawing SK-G-04053 (Appendix A).

## 2.11 Berm Height Reduction and Material Management

### 2.11.1 Functions Provided

Reduce Berm Pressure

Lowering the berm height will reduce exterior pressure on the silo walls as residues are removed.

Remove Berm Material

Removing excess berm material from the immediate vicinity of the silo area will minimize interference and provide temporary control and management until final disposition.

Seal Silo Walls

Depending on the condition of the silo walls as they are uncovered, it may be necessary to minimize infiltration of air into the silo headspace by applying a sealant to the silo walls as they are exposed.

### 2.11.2 Description

The berm material will be removed during Stages II and III of the civil work (Stage I includes silo superstructure foundation installation). Each stage will reduce the overall berm height by approximately 10 feet. This requirement is based on structural modeling of the silos which indicates that the silo walls will be stable if the difference in height between the average residue level inside the silo, and the berm on the outside of the silo, does not exceed 10 feet.

Excavated berm material will be removed from the immediate area, and stored temporarily pending final disposition based on contamination levels in the material, site requirements for backfill, and the availability of the On-Site Disposal Cell. The soil will be stockpiled in accordance with the Removal Action 17 Work Plan. Soil will remain in the controlled stockpile until its final disposition is determined.

As necessary, exposed portions of the silo exterior walls will be coated with a water-based sealant to seal any cracks and reduce air infiltration sufficiently to maintain an adequate negative pressure in the silo without exceeding the capacity of the NRTS.

### 2.11.3 Installation/Operations

Excavation of the berm material surrounding the silos will begin after the superstructure residue retrieval systems, NRTS, and the FRVP are operational. Excavation will be performed through the use of long reach backhoes operating from the base of the berm to minimize the presence of heavy machinery on the berms and to reduce worker exposure by maintaining distance from the silo walls. The use of localized radiation shielding mounted directly on the backhoes will be considered based on actual exposure levels. Berm material will be retrieved in a top down fashion with the excavated material being placed in dump trucks for immediate removal. Berm height will always be maintained greater than the level of residues within the silos. Based on structural considerations for the walls, the height difference between the residue and berms shall not exceed 10 feet.

For purposes of concept clarity, the sketches show Stage II and Stage III of berm excavation. Stage I provided local excavation for superstructure foundation installation. The maximum depth of berm removal at any one time should be 3 to 3.5 feet with the excavation generally proceeding in complete cuts around each silo. The maximum localized cut at any location should be 4 feet. Stage II represents the condition after approximately 10 feet of berm has been removed (See Drawing No. SK-G-04054, Appendix A). This excavation stage should ideally begin after the surface of the residue has been lowered by approximately 5 to 8 feet. Considering that earthwork is most desirably done during May through October, the scheduling of excavation should be coordinated with the projected rate of residue retrieval so that retrieval operations do not have to be interrupted while waiting for suitable weather to excavate berm materials.

Stage III represents the condition after approximately 20 feet of berm materials have been removed (see Drawing No. SK-G-04055, Appendix A) and is the final stage of berm excavation. Stage III will probably be done during the construction season following Stage II with the progress of excavation to suit the guidelines described.

The actual amount of berm lowering for each stage will be allowed to vary slightly to suit actual conditions and the requirements described. After each stage, or whenever excavation is stopped for a period of 4 weeks or more, the disturbed areas will be hydroseeded and covered with an erosion control blanket, such as "Excelsior Mat" or other equivalent mat, to minimize erosion and sedimentation. A silt fence/hay bale barrier will be in place prior to any excavation operation. During all excavation operations the existing stormwater management system surrounding the silos will remain functional and in operation.

Sealant

After each stage of berm lowering, the silo walls will be inspected and a sealant will be applied to the exterior of the silo walls, as deemed necessary, to limit air infiltration to the silo headspace through cracks in the silo walls. The sealant will be applied from a spray device mounted on long reach equipment which allows controlled application of the sealant with minimal overspray while keeping the operator at the base of the berm out of the higher radiation fields next to the silo walls.

Berm Material Management

Berm material which is removed from the silo area will be managed in accordance with RA 17 Work Plan and FERMCO procedure EW-0006, "Management of Excess Soil, Debris, and Waste From a Project." The excavated soil will be stored within the OU-4 or other designated site area in a controlled stockpile for eventual disposition at the On-

Site Disposal Facility (OSDF) or, if soil exceeds OSDF waste acceptance criteria, an off-site disposal facility. The stockpile will be located in an area that does not interfere with silo remediation activities. Excavated soil will be stockpiled for use as backfill within OU-4 as possible and necessary.

# SECTION 3

## PNEUMATIC RETRIEVAL OF METAL OXIDES

Silo 3 contains 5,088 cubic yards of residues, known as cold metal oxides, which were generated at the FEMP site during uranium extraction operations. The residue is a dry powdery material which was placed into the silo pneumatically. Sample results (DOE 1993 and Stone 1995) indicate the material has a low moisture content (less than 10 percent) and an angle of repose of approximately 20 to 30 degrees. Localized areas of agglomerized residue may exist within the silo at the residue surface or along the silo walls due to the infiltration of moisture.

Silo 3 is a large, cylindrical, above-grade, concrete vessel with post tensioned steel reinforcing, similar to the K-65 Silos. The silo is 80 feet in diameter, 36 feet high at the center of the silo, and 26 feet high at the silo wall. Unlike the K-65 Silos, Silo 3 does not have a surrounding berm and its walls are exposed. It also does not have a center sump.

A series of flanged decant ports, spaced a foot apart are located vertically along the east and west walls. Silo 3 has seven major manways in its dome. Four of the openings are 20-inch ID flanged manways located on a circle 25 feet from the center of the dome. A fifth manway is located near the center of the dome. The remaining two openings are approximately 20- and 24-inch ID circular hatches located near the silo walls on the north and east sides, respectively. For more detailed information on the K-65 Silos see the Remedial Investigation Report (DOE 1993).

The residue retrieval systems for Silo 3 will access the silo contents at grade through new penetrations at the base of the silo walls. The retrieval equipment will be housed in Equipment Enclosures (EE) located on the east and west sides of the silo. The EEs will provide containment and environmental controls for the retrieval equipment. Because the floor of the silo is below the existing grade, soil will be excavated and the EE will be placed on concrete pads at the bottom of the excavations.

Two holes, approximately 8 inches in diameter, will be drilled in the silo walls, approximately 180 degrees apart, at the existing decant port locations. Initially, mechanical augers will be inserted several feet into the silos through the new penetrations. The augers will feed the pneumatic transport system and lower the residue level in the silo. Once the level is lowered sufficiently, the augers will be removed and the 8-inch silo penetrations will be enlarged to allow a pneumatic tube to be extended further into the silo to retrieve residue from the center of the silo. Following bulk retrieval operations the Houdini vehicle will be relocated to Silo 3 and deployed in one of the EEs through the enlarged opening for heel removal and discrete object management.

As identified in the Letter Report on Residue Retrieval Methods for Silos 1-3 (PARSONS 1996), the primary advantage of this scenario is the fact that it does not require construction of a superstructure over Silo 3 or dome segment removal. This avoids lifts of heavy equipment over the dome and eliminates the need for personnel to spend significant amounts of time over the dome performing operations and maintenance in an area with significant external dose. Additionally, penetrations made in the silo wall do not immediately access the radon containing dome headspace. The silo walls have 8 inches of concrete which provides more effective shielding than the 4 inches in the silo dome. Operations at grade will be easier to shield, easier to control, and can be performed more time efficiently.

Drawing SK-G-04010, Appendix A, provides a plan view of the silo area and provides a simplified layout. The various subsystems which comprise the overall residue retrieval system are discussed in more detail in the following sections. The Drawing Index SK-X-04163 located in Appendix A provides a list of the Preliminary Design Drawings which have been developed in support of this effort. These drawings are referenced throughout the subsystem descriptions.

## 3.1 Pneumatic Retrieval System

### 3.1.1 Functions Provided

Bulk Retrieval - The pneumatic retrieval system will remove the dry, free flowing metal oxide residues from Silo 3 for transfer to a filter receiver. The system must be able to handle material of varying consistency including clumping and small chunks of agglomerated residue. Drawing SK-F-04077 provides a process flow diagram for the pneumatic retrieval system (Appendix A).

Maintain Containment - The pneumatic retrieval system will prevent the release of residues to the environment.

### 3.1.2 System Description

The system is comprised of the following four major components:

Auger - The auger arrangement is shown in Drawing Nos. SK-M-04207 and SK-M-04206, Appendix A. The auger utilizes a specially constructed 6-inch diameter screw conveyor. The screw conveyor is cantilevered 4 feet into the silo with more than half of its section exposed to the material. The last 12 inches on the auger tip is tapered and a special insert in the tip helps dig into the residue. The cantilevered section of the auger will have teeth to help erode any residue which might have become compacted or hardened. The screw conveyor will be reversible to counteract jams and has an extra large shaft for rigidity. Catalog cuts for the conveyor and its housing are provided at Appendix B-19 and B-20. The auger discharges through a small hopper and an in-line delumper crusher which ensures that the residue is crushed to manageable particle sizes (see Appendix B-21). From the lump breaker, the material is discharged into a small hopper which feeds a rotary airlock (see Appendix B-22) that discharges into the pneumatic conveying system. The pneumatic conveying system is a closed loop system. Residue is removed from the airstream in a filter receiver and conveying air is cooled, and recirculated back to the solids pick-up point beneath the rotary valve in the EE. The hopper on top of the lump breaker is provided with a high level switch which will detect a build-up of material due to overfeeding or pluggage downstream. The auger has a variable speed drive to allow matching the reclaim capacity of the auger to the conveying capacity of the pneumatic conveying system.

Pneumatic Retrieval Tube - The pneumatic tube arrangement, shown in Drawing No. SK-M-04209, Appendix A, is installed in the EE into the silo through an enlarged (4 foot wide by 3 foot high) opening in the silo wall. The pneumatic retrieval tube is constructed with a special head that aids in fluidizing residue. It is also provided with a small pipe with a venturi end that can bring instrument air to the tip of the tube in case of pluggage. The tube head is of a double wall construction where an airflow is induced in the outer tube from the suction applied to the inner tube. The head has a gentle bend that directs the opening of the tubes towards the floor. It is also provided with two casters that help roll the head along the floor.

The pneumatic retrieval tube is made of 5 foot sections which screw together and which are connected in the EE to an end piece with a pneumatic hose. This hose connects the pneumatic retrieval tube to the pneumatic conveying system. Note: The pneumatic conveying system (vacuum blower and filter-receiver) will be located outside of the EE. Residue is removed from the airstream in a filter receiver and conveying air is filtered and recirculated back to the silo headspace. This cycle creates a closed loop system. A simple attachment with an electric hoist and a sheave arrangement makes it possible to advance the tube. Additional 5 foot sections are added manually as required to advance the retrieval tube further into the silo.

Decant Port Air Lance - An air lance, consisting of 5 foot sections of air pipe, is manually inserted horizontally through one of the existing decant ports in the silo wall within the EE. The air lance passes through a clamping device which is bolted to the decant port flange. This device provides a positive seal against residue leakage. Instrument air is injected through the air lance to assist in fluidizing the residue, breaking up clumps, and collapsing ratholes. A sketch of the decant port air lance configuration is provided at Appendix B-23.

Silo Backing Plate - The silo backing plates are approximately 11 feet wide and 9 feet high and conform to the curvature of the exterior of Silo 3. The backing plates are constructed of carbon steel and are welded to a structural frame (see Drawing No. SK-M-04207 and SK-M-04206). Each backing plate is constructed with a vertical sliding door arrangement to accommodate the final 4-foot-wide by 3-foot-high opening (see Appendix B-24). Mounted within the 4.5 by 3.5 foot doorway is a 10-inch flange which will accommodate a 10-inch knife gate valve (see Appendix B-25). Three 9 by 9-inch openings are located along the vertical centerline of the backing plate to allow access to the decant ports with a high pressure lance. Four pins are located in the corners of the backing plate to allow alignment with the EE when it is installed. The backing plate has attachments welded along both outer edges to accommodate hold down cables. The backing plate is sealed to the existing silo wall with grout as described in Subsection 3.1.3.

### 3.1.3 System Utilization

Installation

The backing plates will be installed using the following general steps:

1) The backing plates will be positioned on either side of the silo, centered over the existing decant ports. These areas will have already been excavated and foundations installed as discussed in Subsection 3.7.

2) The backing plates will be provided with temporary support to allow grout placement between the backing plate and the silo wall. Temporary bulkheads will be set on the sides of the plate to seal the opening between the frame and the wall. The plate will be set to maintain an optimum clearance between the plate and the silo wall for the grout installation.

3) A high strength flowable grout will be cast in the space between the plate and the silo wall. The grout will be used to provide a smooth bearing for the plate on the wall without requiring any physical grinding or blasting of the wall surface. The temporary supports and bulkheads will be removed after the grout has set and reached the required strength.

4) Prestressing strands will be attached to the locations prefabricated on each side of the frame. These will be seven-wire single strand tendons of high-strength prestressing steel with an ultimate strength of 270 ksi. The strands will be galvanized to provide corrosion protection while exposed on the surface of the tank wall. The number of strands required will be determined by the finite element analysis of the silo with the penetrations. The strands will be long enough to reach 90 degrees around the silo, plus 4 feet to facilitate use of an overlap anchorage.

5) Each strand will be pulled to a location halfway between the two penetrations. An overlap anchor will be used to anchor and tension the strands one at a time. Stressing of a strand at any given elevation will be done simultaneously on both sides of the silo to ensure a balanced load on the plates and wall. Depending on the results of the finite element analysis of the wall and the plate design, the prestressing of each level of strands may be done in several partial stressing operations.

6) At this point the steel frame will have been sealed and secured against the wall without intruding into the wall structure. Subsequent silo wall coring operations (see Subsection 3.3.2) and installation of the EE can now take place.

The auger equipment is premounted in the EE with an adjustable guide system. Premounting allows construction, installation, and testing of the equipment prior to shipping to the site. Once the EE has been located on its foundation and attached to the backing plate, the auger is aligned and inserted through the flanges in the backing plate using jacks and the guide system. At the completion of auger operations, the auger system is disassembled into smaller components, which are packaged and removed from the EE via the vestibule.

The pneumatic retrieval tube is installed in the EE after the auger equipment has been removed. The tube equipment is brought into the EE through the vestibule using the monorail where it is rigged into place and bolted to the floor. At the completion of operation of the retrieval tube, it is disassembled, packaged, and removed from the EE via the vestibule.

To deploy Houdini, the pneumatic tube must be removed from either of the EEs. A pneumatic hose assembly will be installed (connected to the conveying system) for use by Houdini. Houdini is installed and the EE prepared for Houdini deployment as follows:

1) The TMADS unit is bolted into a support structure and lifted onto the EE where it is secured in place. A flexible boot is attached which seals the bottom of TMADS to the EE roof opening. The pre-engineered roof section and a portion of the monorail are then removed.

2) A tether swing guide with rollers is installed in the EE from the roof.

3) The Houdini access ramp is installed.

Operation - Once the auger is installed and set up in the EE, operation is controlled remotely. The operator uses monitored system parameters and the installed camera system to control operations. Should material flow difficulties occur inside the silo, air pressure is applied through an air lance which can be manually inserted through one of three decant ports along the side of the silo. The compressed air will assist in fluidizing the residue, breaking up clumps, and collapsing ratholes.

Retrieval operations with the pneumatic tube are also controlled remotely. The operator remotely advances the tube into the silo and activates the pneumatic conveying system based on monitored system parameters and the installed camera system. Additional pipe lengths, when required, are manually installed in the EE.

During shutdown of the pneumatic conveying system at the end of each shift or for repairs, it will be necessary to clear the pneumatic transport lines of any holdup material to limit the potential for radiation exposure and/or inadvertent release. To ensure that holdup material is limited, the transport system will continue running for 5 minutes after the retrieval system is stopped. In the case of the auger, this requires stopping and reversing the auger. For the pneumatic retrieval tube and for Houdini, the retrieval tube/wand is pulled back out of the residue and allowed to recirculate air. Fresh instrument air can be injected by the venturi tube to further flush the system with clean air. If pluggage occurs in the pneumatic retrieval tube, the tube can be withdrawn into the EE for removal of the solids. Alternately the tube could be cleared with pressurized air. These options would only be necessary in the most severe cases.

Maintenance - The auger will have periodic required maintenance consisting of lubrication and mechanical adjustments. This maintenance as well as repair or unplanned maintenance will be performed in the EE. The pneumatic retrieval tube has little or no regular maintenance. Preventive maintenance can be satisfied when personnel enter the EE to insert additional sections of tube.

Heel Retrieval - Following bulk retrieval operations, Houdini will be deployed through the enlarged wall opening. Houdini may deploy a manipulator held pneumatic vacuum tube for local retrieval operations. The vacuum tube hose will connect to the existing pneumatic transfer system. Houdini can also push residue across the silo floor to the other retrieval system using its vehicle-mounted plow blade.

D&D and System Removal - None of the residue retrieval equipment have any foreseeable use in D&D. The retrieval equipment can be disassembled in the EE and packaged for disposal.

## 3.2 Houdini Robotic System

### 3.2.1 Functions Provided

Heel Removal

Following bulk retrieval, Houdini may be deployed into Silo 3 to remove residues which could not be accessed by the bulk retrieval system.

Discrete Object Management

Following bulk retrieval the vehicle may be deployed in the silo to manage discrete objects which were not retrievable by bulk retrieval operations.

Decontamination and Decommissioning

Houdini may assist in the inspection and final D&D of Silo 3 after the completion of retrieval operations.

### 3.2.2 System Description

The Houdini system is comprised of five major components as described in Subsection 2.2 for Silos 1 and 2. For Silo 3, however, the EE will be prepared as described in Subsection 3.1.3 and the system will be employed as described below and shown in Drawing No. SK-M-04208, Appendix A.

### 3.2.3 System Utilization

Installation

The Houdini robotic system is expected only to be used to support heel retrieval operations at Silo 3. Therefore, the design is such that the system will not be installed in Silo 3 until the completion of bulk retrieval operations. Prior to this time it will be used in either Silo 1 or 2. Since the Houdini system will service all three silos, it will be readily transferrable between silos.

The Houdini system is installed manually. The TMADS is bolted onto its support stand which is then rigged and mounted above the EE using a small mobile crane. A flexible boot seals the TMADS unit to the EE roof opening. The PDCU unit will be located adjacent to the EE on a concrete pad. Cables are run between the TMADS and the PDCU and from the PDCU to the control console in the control trailer. A permanent set of cables and hoses will be installed and all electrical and hydraulic connections to the PDCU will have quick disconnects to minimize set-up and take-down time.

Operations

The Houdini vehicle is deployed remotely from the TMADS through its bottom door. The vehicle is lowered into the EE through an opening in the roof. Since the TMADS is sealed to the EE, air pressure is maintained slightly negative with respect to the atmosphere by the EE ventilation system. Once the vehicle is hanging in the EE it will unfold into its deployed position and be lowered onto the EE floor. From this position it can travel under its own power up the EE ramp and proceed into the silo. The vehicle can select and carry a pneumatic hose for local vacuuming as necessary within the silo as well as perform other heel retrieval support tasks.

Maintenance

Minor maintenance and system checks will be performed on the vehicle in its stowed position in the TMADS prior to mounting on the EE. Access to the vehicle is achieved by removing the appropriate plate to allow access. Required maintenance after initial deployment may be performed in the EE. Any major maintenance will require that the TMADS (or PDCU if applicable) be removed from the immediate silo area to reduce radiological exposure to the maintenance personnel.

In the event that the vehicle fails, it can be dragged back into the EE by the tether reel. A roller assembly installed in the EE will assist in tether retrieval and guide the tether back into the TMADS. Once the vehicle is pulled from the silo, manual support by personnel may be required in the EE to successfully retrieve a failed Houdini vehicle into TMADS.

Removal/D&D

At the completion of its use in a specific silo, the vehicle will be gross decontaminated as possible and stowed and sealed in the TMADS module to provide shielding and containment during transport. The TMADS box will be swiped for radiological contamination prior to removal from the EE and will be further decontaminated or packaged if required.

Houdini may be used to perform internal silo concrete inspection following heel retrieval. It could also be used to spray the wall with sealant prior to demolition and could be configured to take swipe samples for concrete contamination evaluation.

## 3.3 Silo Wall Cuts

### 3.3.1 Functions Provided

Equipment Access - Silo wall cuts will allow access to the silo residue by the pneumatic retrieval equipment and the Houdini vehicle for heel removal and object management.

Maintain Silo Integrity - The cuts will ensure the continued ability of the silo to contain silo residues and prevent release to the environment.

### 3.3.2 System Description

Silo access is provided through a sequence of new penetrations in the silo walls.

Silo Banding - The post-tensioning construction of Silo 3 involved wrapping numerous steel wires around the circumference of the concrete tank. The steel wires were tensioned and then covered with a layer of shotcrete to protect them from the elements. To penetrate the silo wall for access a significant number of these wires must be severed and it is necessary to retain the cut wires and keep them from breaking out of their shotcrete layer. These functions are performed by the silo backing plate described in

Subsection 3.1.2. The backing plates are held in place by tensioning cables which place compression on the silo walls. The backing plates are sealed to the silo wall with grout. These tensioning forces additionally replace the forces of the wires which are to be subsequently cut as well as keeping them from breaking out of the outer shotcrete layer. The wire tensioning cables are galvanized and can remain in place throughout the period of residue retrieval and subsequent silo D&D.

Silo Wall Drilling - An initial 8-inch diameter hole will be drilled in the silo wall through a 10-inch flange in the backing plate at each access location to provide access for the auger retrieval equipment. The hole will be drilled using a diamond tipped concrete coring bit and an electrically driven concrete drill. The following basic steps are taken to accomplish the 8-inch cut:

1) A 10-inch knife gate valve is mounted on the backing plate flange. The interior of the flange was filled with grout prior to installation.

2) The drill and bit are mounted on the backing plate and enclosed in a containment box.

3) A hole is then drilled through the gate valve, grouted flange, and concrete wall. Note: the gate valve should be in the open position prior to drilling. A small amount of water (<2 gallons) is used during the drilling operation. The majority of this water will flow back into the containment box, where it will be removed with a vacuum.

4) Once breakthrough is achieved, the drill is backed out of the opening. The drilled grout provides a sealing sleeve to prevent the uncontrolled release of silo residue during this operation. Once the bit and concrete plug clear the gate valve, the gate valve is shut, sealing the residue in the silo. A blank flange is installed on the outside of the valve flange for additional containment until the EE is installed.

5) Any residue which has escaped the gate valve is vacuumed from the containment box (along with cooling water). The exterior of the valve is decontaminated (if necessary) and the box and drill arrangement are sealed and removed.

6) At this point the new opening has been sealed and secured. Installation of the EE can now proceed.

A sketch of the drill/containment arrangement and catalog cuts for core drilling equipment are located in Appendix B-26, B-27, and B-28.

Silo Wall Cutting - Following completion of retrieval operations with the auger. The auger equipment is removed and a local vacuuming device or vacuum hose is manually installed in the 10-inch gate valve via a bag-in/bag-out operation. The vacuuming device is used to remove any remaining residue in the seal. In the event that the inflatable insert seal develops a small leak, a foam mixture can be pumped into the seal to fill and seal the puncture.

Removal/D&D

The silo insert will remain in place until preliminary D&D is completed on the silo. The insert spray rings will continued to be used for gross decontamination of equipment leaving the silo. The insert will be constructed of stainless steel to facilitate its decontamination prior to final disposition.

## 2.5 Equipment Room Ventilation

### 2.5.1 Functions Provided

Directional Airflow

The control of contamination is accomplished through the use of differential air pressure and directional airflow. By maintaining air pressure in the ER at a negative pressure with respect to the atmosphere and at a positive pressure with respect to the silo headspace an inherent directional airflow from areas of less potential contamination to areas of greater contamination is created. The release of particulate contamination from ER discharge air will be prevented through the use of air cleaning devices (particulate filtration). This air will not be treated for radon due to the limited concentrations expected in the ER throughout the project.

Ventilate and Cool

Ventilation capability through the ER and the vestibule is provided to ensure that electrical equipment is maintained at temperatures less than National Electrical Manufacturers Association (NEMA) equipment ratings during hot weather. Airflow through the ER and vestibule is maintained during periods of occupancy to promote a comfortable, healthy, safe environment for workers.

### 2.5.2 System Description

Ventilation is comprised of four major components as shown on Sketch SK-F-04075 (Appendix A), and described as follows.

Air Cleaning Devices

The air cleaning devices are used to remove dust particles from the ventilated air prior to its exhaust to the atmosphere.

immediate vicinity of the opening on the inside of the silo. The silo interior is inspected with the dome mounted cameras to ensure residue is cleared from the inside of the opening. The 8-inch penetration is then enlarged to the final 4-foot wide by 3-foot tall opening. This opening is cut through the preinstalled silo backing plate which provides mounting for the silo slide door. A hand held, hydraulic, diamond tipped concrete saw is used for this enlargement. The hole is cut manually by an operator dressed in full contamination clothing and supplied air. During the cutting evolution the cut slab is secured in place with anchor bolts. Local HEPA filtered vacuum and subsequent decontamination are used to reduce the contamination levels in the EE. After the cut is complete the same anchor bolts are used to rig and remove the slab using the monorail hoist and a hand winch. As the slab clears the opening, the slide door is shut to isolate the EE from the silo. The slab is then packaged (bagged) for removal from the EE. The packaged slab is removed from the ER using the monorail hoist. A catalog cut for a typical concrete cutout saw is located in Appendix B-29.

## 3.4 Equipment Enclosure/Silo Ventilation

### 3.4.1 Functions Provided

Containment - Prevent the spread of contamination by maintaining air pressure in the EE at a negative pressure with respect to the atmosphere and air pressure in the silo headspace negative with respect to the EEs. The release of particulate contamination from EE and silo discharge air will be prevented through the use of air cleaning particulate filtration devices and local vacuuming devices. Additionally, the silo headspace discharge air may be treated to reduce radon levels, if necessary.

Ventilate and Cool - Maintain airflow through the EE to ensure that electrical equipment is maintained at temperatures less than NEMA equipment ratings during hot weather. Provide sufficient airflow through the EE during periods of occupancy to promote a comfortable, healthy, safe environment for workers.

### 3.4.2 System Description

Ventilation is comprised of four major components as described below and shown on Drawing SK-F-04077 (Appendix A).

Air Cleaning Devices

The air cleaning devices are used to remove dust particles from the ventilated air prior to exhausting to the atmosphere. Each assembly unit will be supplied with a prefilter section, test sections, and a HEPA filter section. Differential pressure gauges will be installed for each prefilter and HEPA filter. An alarm will be provided locally and at the FRVP control room for high and low differential pressure across prefilters and HEPA filters (see Appendix B-14 for typical filter unit).

Exhaust Fan

The silo exhaust fan is provided with variable speed control to allow its operation at the different flow rates required throughout retrieval operations. During auger retrieval, there is no significant airflow between the EE and the silo (openings are small, well sealed and generally submerged), therefore, only a small airflow is required to maintain a negative air pressure in the headspace. After the silo penetrations have been enlarged and uncovered, a larger airflow will be required to maintain a negative air pressure in the silo relative to the EEs (see Appendix B-30 for typical exhaust fan).

The EE exhaust fans are used to maintain a design volume flow rate from the EE and will be interlocked with a motorized air inlet damper to maintain a negative pressure in the EE. EE exhaust fans will be also interlocked with silo exhaust fans to insure air pressure in the silo headspace remains negative with respect to the EEs. The exhaust fans will be installed on a concrete pad external to the EEs.

Stack

Air discharged from both EEs and the silo headspace will be discharged through a single stack. The stack will terminate above the EE roof and structurally designed to withstand maximum predicted wind load. Isokinetic sampling will be installed in the stack to provide emission monitoring of particulate. Alternately, these exhausts could be piped directly to the FRVP off-gas system or the NRTS to eliminate the need for this stack.

Air Inlet Damper

A motor-operated air inlet damper located in the outer vestibule wall provides a controlled influx of outside air through the vestibule and into the EE while maintaining the EE at a negative pressure relative to atmosphere. An additional damper will be provided on the silo dome to prevent excessive negative pressures in the silo headspace. Appendix B-16 provides a catalog cut for a typical inlet air damper.

### 3.4.3 System Utilization

Installation

The air cleaning devices, fans, and stack will be installed on the ground next to the silo after installation of the EEs.

Operations

As depicted in DWG-F-04077, airflow in the EE will be as follows: outside air will enter through a motorized air inlet damper in the vestibule, move across the vestibule, enter the EE through a second manual damper in the vestibule/EE wall, and then be exhausted through air cleaning devices by the EE exhaust blower into the monitored exhaust stack. This will provide for directional airflow from the highest relative pressure (atmosphere) through the vestibule and EE. The silo exhaust fan will maintain a negative pressure in the silo headspace with respect to the EE. Therefore, any airflow between the silo and EE will be into the silo.

During auger retrieval, air will enter the silo through the air control damper. Additionally, some infiltration may occur through minute cracks which may exist in the silo walls and dome. If air lancing is required through the decant ports to break up clumping and prevent bridging around the auger, the injected air will also be exhausted through the silo exhaust fan.

During auger retrieval the pneumatic retrieval system is at a negative pressure with respect to the silo, EE, and atmosphere. It is also a closed system so there is no air flow to, or from, it and the EE or the silo.

Following enlargement of the wall penetrations (pneumatic tube or Houdini operations) an additional quantity of air will enter the silo through the EE openings and be drawn into the silo due to the differential pressures.

When the EE is occupied or when temperatures approach 100 degrees F, the exhaust fan will be started to provide ventilation and cool the enclosure. Operational spares (HEPA filters) will be provided for the EE and silo ventilation systems. Low and high differential pressure alarms will be provided for prefilters and HEPA filters to indicate a leak in the filters or time to change filters.

Isokinetic stack samplers will determine and record the total quantity of air released to the atmosphere and identify the quantity and concentration of radionuclide emissions.

Maintenance

Except for the air inlet damper, all equipment requiring maintenance will be external to the EE. Filter replacement will be by bag-in/bag-out operation. The stack sampling station will require a well-lighted access platform for inspections and/or service.

Removal/D&D

The EE and silo ventilation systems will remain in operation throughout D&D operations until containment is no longer required on Silo 3.

## 3.5 Operational Control System

### 3.5.1 Functions Provided

Monitor Operations

The operational control system will provide visual feedback on the activities of equipment and personnel in the EE during operations and maintenance.

Monitor Retrieval System

The system will provide remote monitoring of key retrieval system component parameters to ensure the safe operation of the retrieval system while minimizing the need for manual inspections. System parameters will include flow, pressures, levels, etc., to be determined during Title I/II design of the residue retrieval system consistent with the established control philosophy.

Remote Operability

The operational control system will allow remote operation and control of primary retrieval functions necessary to minimize manual operations in the EE for routine operation. This will be accomplished by utilizing a DCS. The system is conceptually presented by Sketch SK-N-04295 (Appendix A).

### 3.5.2 System Description

Table 3-1 lists the functions of each piece of major equipment which can be operated remotely. All remotely operated equipment will have local override and lockout capability as necessary.

Operation of the residue retrieval systems must be integrated with operational control of both the Houdini system, and the FRVP (including NRTS). Although there may be separate operators to control functions specific to the different systems, adequate communications must be provided so that operations can be closely coordinated. As an example, control of some equipment (cameras) may be shared and system parameters must be available at multiple locations.

Although the Houdini system is provided with its own independent command trailer, the Houdini console could be relocated to a common control area within the FRVP. Since the residue retrieval systems are normally remotely operated, their control center could also be located within a common FRVP control area. The details concerning the location of the residue retrieval system control center and Houdini Command Center will be defined during detailed residue retrieval design.

Table 3-1 - Silo 3 Remotely Operated Functions

| Equipment | Function | Where Controlled |
|---|---|---|
| Auger | Basic Auger Functions | FRVP Control |
| Pneumatic Retrieval Tube | Compressed Air<br>Vacuum On/Off<br>Advance/Retract | FRVP Control |
| Houdini TMADS | Open/Close Door<br>Raise/Lower Tether | Houdini Control |
| Houdini Vehicle | All Vehicle Operations | Houdini Control |
| Houdini PDCU | Open Main Breaker | Houdini Control |
| Silo Slide Door | Open/Close Door | FRVP Control |
| Knife Gate Valve | Open/Close Gate | FRVP Control |
| EE Ventilation Exhaust Fan | On/Off Exhaust Fan | FRVP Control |
| Silo 3 Exhaust Fan | On/Off Exhaust Fan | FRVP Control |
| EE Cameras | Pan, Tilt, and Zoom | FRVP Control |

## 3.6 Equipment Enclosure

### 3.6.1 Functions Provided

Provide Containment

The EE will provide containment for the residue retrieval system and during the 4-foot by 3-foot wall cut. It will prevent the release of particulate contamination to the environment and provide a means for workers and equipment to enter and exit without spreading contamination.

Shield Workers

The EE will provide shielding to reduce personnel radiation exposure consistent with ALARA.

Support Retrieval Equipment

The EE will provide a stable operational platform for the residue retrieval equipment. As necessary, it will protect the residue retrieval and support equipment from the elements and provide a means to maneuver and transport equipment within the EE as needed to support operations and maintenance.

### 3.6.2 System Description

Equipment Enclosure

Two identical and separate EEs are provided for Silo 3. Each EE module has overall dimensions (including vestibule) of 10 feet wide by 32 feet long by 13 feet tall and is located on its foundation pad immediately adjacent to the silo wall. An opening in the front of the EE (facing the silo) is connected and sealed to the silo backing plate for containment. The retrieval equipment is installed in the main portion of the EE. The EE is constructed of metal siding on a structural steel frame with a steel plate floor. A door is located for ingress and egress of personnel and equipment from the EE via the vestibule.

The EE is provided with lighting. The ventilation system is discussed in Subsection 3.4. Other support systems included in the EE are breathing air connections, compressed air connections, 120 and 240 volt electrical receptacles, a fire extinguisher, radiation and radon monitors, and an intercom system for communications with the control room and the Houdini command trailer.

Vestibule

The vestibule is a separate room within the EE. Its dimensions are 10 feet wide by 10 feet long by 13 feet tall. The vestibule construction is the same as the EE. The vestibule provides space for personnel changeout and equipment survey prior to exiting. A set of double doors are located for personnel and equipment ingress and egress from the vestibule. The vestibule is provided with lighting, breathing air, fire extinguishers, 120 volt electrical receptacles, radiation monitors, and an intercom.

Monorail System

A 4-ton monorail system is mounted on the structural roof members of the EE and runs along the center axis of the EE from the silo wall to the exterior of the EE/vestibule. A trolley located on the monorail is used to lift the auger/conveyor and the pneumatic tube. The trolley is locally operated can be locked into place in the EE in their deployment positions.

Camera System

A closed circuit video system provides for monitoring both equipment and personnel operations in the EE and equipment operations within the silo. A single color camera is mounted in one corner of the EE while another two additional cameras are provided in two of the outer manways of the silo dome. The cameras are connected to the central control room in the FRVP. The cameras are provided with a pan and tilt mechanism operated by a manipulator from the control room. Those mounted in the silo dome outer manways will be provided with lights and will be similar to the Silo 1 and Silo 2 camera units shown in Appendix B-4. The Silo 3 dome-mounted cameras however will be supported at the silo dome.

### 3.6.3 System Utilization

Installation

The EE and vestibule are constructed and tested as a single module. To reduce personnel exposure, fabrication and testing will be performed to the maximum extent possible at the fabricator's shop. Equipment including the monorail, hoists, cameras, and other control and auxiliary equipment will also be installed and tested. Each EE will be shipped to the site on a flatbed truck. The EE will be lifted and installed onto the preconstructed foundation at the base of the silo using a small mobile crane. The EE is positioned and sealed to the silo backing plate through a flexible connection after the wall has been banded and the backing plate installed as discussed in Subsection 3.1.3.

Operation

During normal operation the EE is unmanned and the retrieval equipment (auger/conveyor or pneumatic tube) is operated remotely. Major personnel activities in the EE will consist of entry to remove the auger system and to add pneumatic retrieval tube sections. It is likely that the interior of the EE will become radiologically contaminated during retrieval operations, following removal of the auger system and use of the Houdini vehicle. A local vacuum system will be provided to remove excess residue from equipment withdrawn from the silo and to help limit contamination of the EE during these activities. Ingress and egress from the EE will be radiologically controlled, using the vestibule as a control point.

Maintenance

Periodic maintenance required on the EE-mounted equipment is limited to routine greasing of the monorail trolley and hoists, relamping as necessary, and standard maintenance on the camera systems. Cameras, monitors, detectors, and a hoist will be mounted to allow easy removal and replacement. If a component fails, it will be replaced and the failed component will be shop repaired.

D&D

The EE is left in place at the completion of heel retrieval to maintain containment. It can be used as a means of access and egress to the silo for decontamination equipment. The silo demolition approach will determine whether the EE will be removed prior to silo demolition or remain in place. The interior of the EE is constructed with a strippable coating to assist in its final decontamination.

## 3.7 Equipment Enclosure Excavation/Foundation

### 3.7.1 Functions Provided

Provide Access to Silo Base - The floor of Silo 3 is approximately 1.75 feet lower than the existing grade. Excavation of approximately 6 feet of soil in the immediate vicinity of the EE is required so that the EE is low enough to permit penetration into the silo wall near the silo floor to allow for greater retrieval capability.

Support Equipment Enclosure - The EE must be placed on a stable platform to conduct retrieval operations. A means must be provided to remove stormwater which may flow into the excavation. A means must be provided to transfer personnel and equipment to and from the EE.

### 3.7.2 System Description

Two areas will be excavated on opposite sides of the silo where the EEs are to be constructed. As shown on Drawing No. SK-C-04010, Appendix A, the excavations will be to a depth of approximately 6 feet and will have a sloping side on the south side and the end opposite the silo, and a vertical retaining wall on the north side, as well as vertical concrete walls near the silo. A concrete slab foundation will be poured in the bottom of the excavation to support and accommodate the EE module with 4 feet of clearance on the south side, 30 inches of clearance on the north side, and 10 feet of clearance at the end opposite the silo to allow the equipment to be removed from the EE module to be lifted out of the excavation. Each excavation will have an integral sump and pump to allow for collection and removal of stormwater. Stormwater collected in the sump will be discharged via splash pads to existing surface drainage features nearby.

All equipment must be decontaminated and surveyed prior to leaving the EE module to ensure that the 10-foot loading/unloading area remains uncontaminated. A small mobile crane will be used to lift equipment into and out of the excavation. The area adjacent to the north side of the excavation will be accessible by either a flatbed truck or a forklift.

### 3.7.3 System Utilization

Installation - The excavation will be performed early in the project to allow construction of the foundation with sufficient time to support installation of the silo backing plate and the EE. If perched water units are encountered during excavation of the foundation, the area will be locally dewatered during foundation installation, as necessary, depending on the quantity and recharge rate of the perched unit.

Handling requirements for the pumped perched water will depend on the extent of contamination actually encountered.

D&D/Removal - Removal of the foundation pad can be performed in sequence with and in the same manner, as the silo foundation.

# SECTION 4

# REFERENCES


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(Stone 1995) Stone, J., July 25, 1995. FERMCO Interoffice Memorandum. Subject: Silo 3 Material Properties - Angle of Repose. FERMCO M: CRUP (CRU4/EES): 95-0053.

# APPENDIX A

## CONCEPTUAL DESIGN DRAWINGS RESIDUE RETRIEVAL SYSTEMS SILOS 1, 2, AND 3

*Note: Drawings are included in an 11 by 17 inch format for information and have been issued separately as full size drawings.*

# INDEX OF DRAWINGS

| INDEX CODE NO. | DRAWING NO. | SHEET NO. | REVISION NO. | DRAWING TITLE | REMARKS |
|---|---|---|---|---|---|
| | SK-X-04163 | X0001 | B | DRAWING INDEX | |
| | | | | | |
| | SK-G-04050 | G0001 | B | CIVIL - SITE PLAN | |
| | SK-G-04052 | G0002 | B | CIVIL - UTILITY PLAN - STAGE I,II, AND III | |
| | SK-G-04053 | G0003 | B | CIVIL - STAGE I - FOUNDATION GRADING | |
| | SK-G-04054 | G0004 | B | CIVIL - STAGE II - BERM GRADING | |
| | SK-G-04055 | G0005 | B | CIVIL - STAGE III - BERM GRADING | |
| | | | | | |
| | SK-S-04161 | S0001 | B | STRUCTURAL - PLANS - SILO 1 AND 2 SUPERSTRUCTURE | |
| | SK-S-04162 | S0002 | B | STRUCTURAL - ELEVATION - SILO 1 AND 2 SUPERSTRUCTURE | |
| | | | | | |
| | SK-F-04075 | F0001 | B | PROCESS - PROCESS FLOW DIAGRAM - NEW RADON TREATMENT SYSTEM & EQUIPMENT ROOM HVAC | |
| | SK-F-04076 | F0002 | B | PROCESS - PROCESS FLOW DIAGRAM - HYDRAULIC RETRIEVAL, SILO 1 & 2 | |
| | SK-F-04077 | F0003 | B | PROCESS - PROCESS FLOW DIAGRAM - PNEUMATIC RETRIEVAL, SILO 3 | |
| | | | | | |
| | SK-M-04219 | M0001 | B | MECHANICAL PROCESS - PIPING AND INSTRUMENTATION DIAGRAM - SYMBOLS AND LEGEND SHEET | |
| | SK-M-04220 | M0002 | B | MECHANICAL PROCESS - PIPING AND INSTRUMENTATION DIAGRAM - HYDRAULIC RETRIEVAL, SILO 1 AND 2 | |
| | SK-M-04296 | M0003 | A | MATERIAL HANDLING - PIPING AND INSTRUMENTATION DIAGRAM - SILO 3 MATERIAL RETRIEVAL SYSTEM | |
| | SK-M-04295 | M0004 | A | INSTRUMENTATION - CONTROL SYSTEM ARCHITECTURE DRAWING - SHEET 1 | |
| | | | | | |
| | SK-M-04094 | M0001 | B | MATERIAL HANDLING - GENERAL ARRANGEMENT - PLAN - HYDRAULIC RETRIEVAL SILO 1 & 2 | |
| | SK-M-04095 | M0002 | B | MATERIAL HANDLING - GENERAL ARRANGEMENT - ELEVATION - HYDRAULIC RETRIEVAL SILO 1 & 2 | |
| | SK-M-04207 | M0003 | B | MATERIAL HANDLING - FIRST STAGE OF MATERIAL RECLAIM - AUGER/PNEUMATIC CONVEYING SYSTEM PLAN | |
| | SK-M-04208 | M0004 | B | MATERIAL HANDLING - FIRST STAGE OF MATERIAL RECLAIM - AUGER/PNEUMATIC CONVEYING SYSTEM ELEVATION | |
| | SK-M-04209 | M0005 | B | MATERIAL HANDLING - THIRD STAGE OF MATERIAL RECLAIM - PNEUMATIC CONVEYING SYSTEM ELEVATION | |
| | SK-M-04200 | M0006 | B | MATERIAL HANDLING - FOURTH STAGE OF MATERIAL RECLAIM - HOLDING DEPLOYMENT ELEVATION | |
| | SK-M-04294 | M0007 | A | MATERIAL HANDLING - GENERAL ARRANGEMENT - PARTIAL PLAN - HYDRAULIC RETRIEVAL SILOS 1 & 2 | |
| | | | | | |
| | SK-E-04001 | E0001 | A | ELECTRICAL - RESIDUE RETRIEVAL SUBSTATION - SINGLE LINE DIAGRAM | |
| | SK-E-04002 | E0002 | A | ELECTRICAL - SILO #1 & SILO #2 MOTOR CONTROL CENTERS - SINGLE LINE DIAGRAM | |
| | SK-E-04004 | E0003 | A | ELECTRICAL - SILO #3 MOTOR CONTROL CENTER - SINGLE LINE DIAGRAM | |

NOTES

1. THIS DRAWING PACKAGE REPRESENTS THE CONCEPTUAL DESIGN FOR RESIDUE RETRIEVAL SYSTEMS FOR SILOS 1, 2, AND 3 FOR THE FRVP.

| REF DWG NO. | DRAWING TITLE |
|---|---|
| | |

PRELIMINARY
NOT FOR CONSTRUCTION

| REV | DESCRIPTION | |
|---|---|---|
| B | ISSUED FOR CONCEPTUAL DESIGN | N/A |
| A | 90% CONCEPTUAL DESIGN PACKAGE | N/A |

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CINCINNATI, OHIO

SILO SUPERSTRUCTURE DESIGN FOR FRVP
RESIDUE RETRIEVAL CONCEPTUAL DESIGN

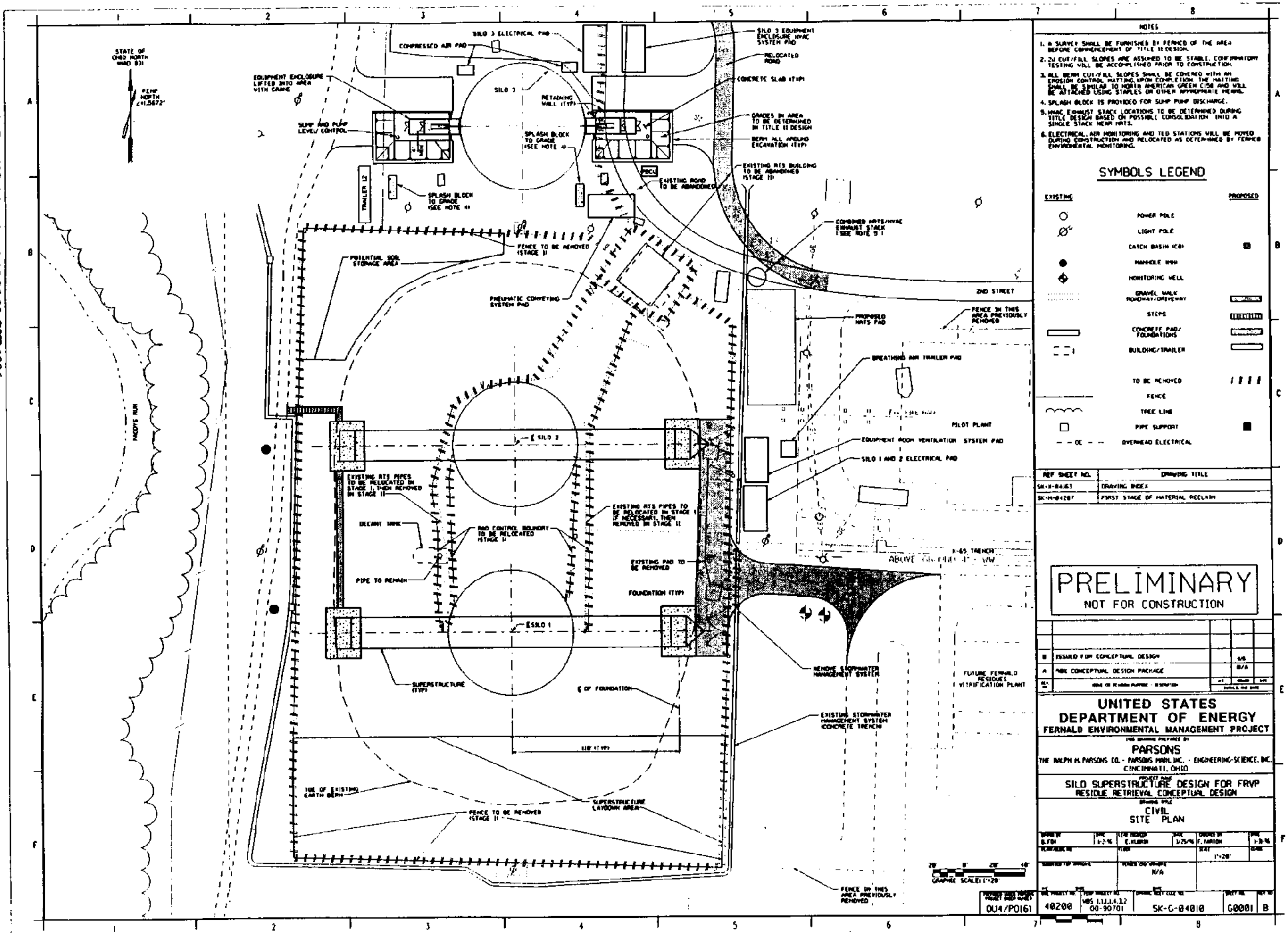
DRAWING INDEX

SCALE: NONE

N/A

OU4/P0161 | 40200 | WBS 1.1.1.1.4.3.2 00-90701 | SK-X-04163 | X0001 | B

skx04163.m po161@ws318. Thu Mar 28 09:42:58 CST 1996


NOTES
1. A SURVEY SHALL BE FURNISHED BY FERMCO OF THE AREA BEFORE COMMENCEMENT OF TITLE II DESIGN.
2. 2:1 CUT/FILL SLOPES ARE ASSUMED TO BE STABLE. CONFIRMATORY TESTING WILL BE ACCOMPLISHED PRIOR TO CONSTRUCTION.
3. ALL BERM CUT/FILL SLOPES SHALL BE COVERED WITH AN EROSION CONTROL MATTING UPON COMPLETION. THE MATTING SHALL BE SIMILAR TO NORTH AMERICAN GREEN C150 AND WILL BE ATTACHED USING STAPLES OR OTHER APPROPRIATE MEANS.
4. SPLASH BLOCK IS PROVIDED FOR SUMP PUMP DISCHARGE.
5. HVAC EXHAUST STACK LOCATIONS TO BE DETERMINED DURING TITLE DESIGN BASED ON POSSIBLE CONSOLIDATION INTO A SINGLE STACK NEAR HATS.
6. ELECTRICAL, AIR MONITORING AND TLD STATIONS WILL BE MOVED DURING CONSTRUCTION AND RELOCATED AS DETERMINED BY FERMCO ENVIRONMENTAL MONITORING.
SYMBOLS LEGEND
EXISTING
PROPOSED
POWER POLE
LIGHT POLE
CATCH BASIN (CB)
MANHOLE (MH)
MONITORING WELL
GRAVEL WALK ROADWAY/DRIVEWAY
STEPS
CONCRETE PAD/ FOUNDATIONS
BUILDING/TRAILER
TO BE REMOVED
FENCE
TREE LINE
PIPE SUPPORT
OVERHEAD ELECTRICAL
REF SHEET NO.
DRAWING TITLE
DRAWING INDEX
FIRST STAGE OF MATERIAL RECLAIM
PRELIMINARY
NOT FOR CONSTRUCTION
ISSUED FOR CONCEPTUAL DESIGN
PRE CONCEPTUAL DESIGN PACKAGE
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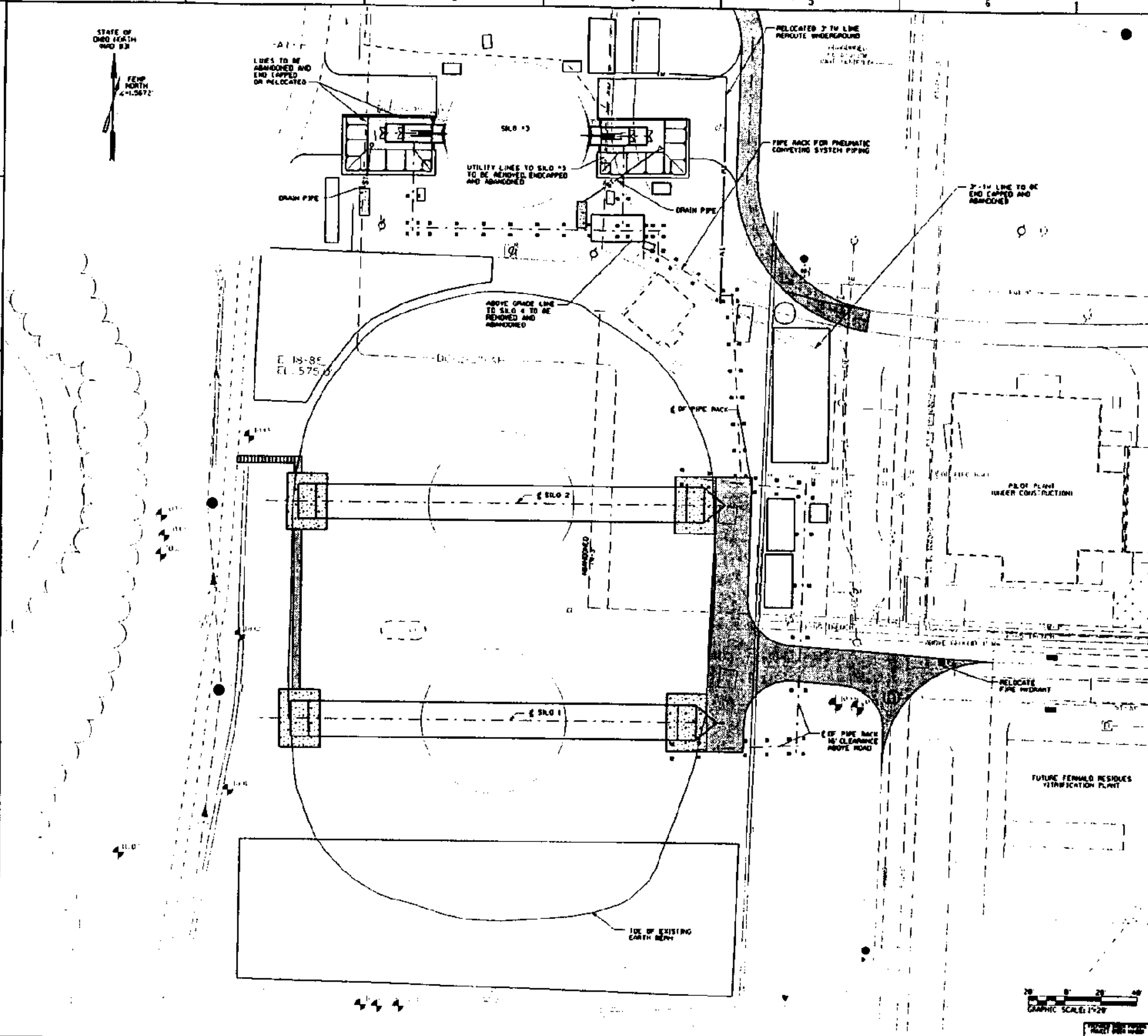
CINCINNATI, OHIO
SILO SUPERSTRUCTURE DESIGN FOR FRVP
RESIDUE RETRIEVAL CONCEPTUAL DESIGN
CIVIL
SITE PLAN
N/A
1"=20'
40200
OU4/PO161
SK-C-04010
G0001
B
GRAPHIC SCALE: 1"=20'
STATE OF OHIO NORTH NAD 83
FEMP NORTH
PADDYS RUN
SILO 3 ELECTRICAL PAD
COMPRESSED AIR PAD
SILO 3 EQUIPMENT ENCLOSURE HVAC SYSTEM PAD
RELOCATED ROAD
CONCRETE SLAB (TYP)
EQUIPMENT ENCLOSURE LIFTED INTO AREA WITH CRANE
SUMP AND PUMP LEVEL CONTROL
SILO 3
RETAINING WALL (TYP)
SPLASH BLOCK TO GRADE (SEE NOTE 4)
GRADES IN AREA TO BE DETERMINED IN TITLE II DESIGN
BERM ALL AROUND EXCAVATION (TYP)
EXISTING RTS BUILDING TO BE ABANDONED (STAGE II)
EXISTING ROAD TO BE ABANDONED
TRAILER 12
COMBINED HATS/HVAC EXHAUST STACK (SEE NOTE 5)
FENCE TO BE REMOVED (STAGE II)
POTENTIAL SOIL STORAGE AREA
PNEUMATIC CONVEYING SYSTEM PAD
2ND STREET
FENCE IN THIS AREA PREVIOUSLY REMOVED
PROPOSED HATS PAD
BREATHING AIR TRAILER PAD
PILOT PLANT
EQUIPMENT ROOM VENTILATION SYSTEM PAD
SILO 1 AND 2 ELECTRICAL PAD
SILO 2
SILO 1
EXISTING RTS PIPES TO BE RELOCATED IN STAGE I, THEN REMOVED IN STAGE II
DECANT TANK
RAD CONTROL BOUNDARY TO BE RELOCATED (STAGE II)
PIPE TO REMAIN
EXISTING RTS PIPES TO BE RELOCATED IN STAGE I IF NECESSARY, THEN REMOVED IN STAGE II
EXISTING PAD TO BE REMOVED
FOUNDATION (TYP)
K-65 TRENCH
REMOVE STORMWATER MANAGEMENT SYSTEM
FUTURE FERNALD RESIDUES VITRIFICATION PLANT
SUPERSTRUCTURE (TYP)
℄ OF FOUNDATION
EXISTING STORMWATER MANAGEMENT SYSTEM CONCRETE TRENCH
TOE OF EXISTING EARTH BERM
SUPERSTRUCTURE LAYDOWN AREA
FENCE TO BE REMOVED (STAGE II)
FENCE IN THIS AREA PREVIOUSLY REMOVED




NOTES

1. REQUIREMENTS FOR REMOVAL, MODIFICATIONS OR RELOCATION OF UTILITIES FOR THE CRANE PADS WILL BE FINALIZED AFTER DETERMINATION OF THE RIGGING PLAN. RIGGING CONCEPTS ARE DISCUSSED IN THE RIGGING AND ASSEMBLY CONCEPTUAL PLAN.

## SYMBOLS LEGEND

| EXISTING | | PROPOSED |
|---|---|---|
| ○ | POWER POLE | |
| Ø | LIGHT POLE | |
| | CATCH BASIN (CB) | ⊡ |
| ● | MANHOLE (MH) | |
| ◈ | MONITORING WELL | |
| | GRAVEL WALK ROADWAY/DRIVEWAY | |
| | STEPS | |
| | CONCRETE PAD/ FOUNDATIONS | |
| | BUILDING/TRAILER | |
| | FENCE | |
| | TREE LINE | |
| □ | PIPE SUPPORT | ■ |
| | STORM SEWER | — ST — |
| | FIRE PROTECTION | |
| — TW | PROCESS WATER | — TW — |
| — CE | CONTAMINATE WATER | |
| — FT | FILTRATE OR EFFLUENT | |
| — SD | SUB-SURFACE DRAINAGE | |
| SL | SUMP LIQUOR | |
| | OVERHEAD ELECTRICAL | |

| REF DWG NO. | DRAWING TITLE |
|---|---|
| SK-I-04163 | DRAWING INDEX |

PRELIMINARY
NOT FOR CONSTRUCTION

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|---|---|---|---|---|
| B | ISSUED FOR CONCEPTUAL DESIGN | | N/A | |
| A | 90% CONCEPTUAL DESIGN PACKAGE | | N/A | |

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SILO SUPERSTRUCTURE DESIGN FOR FRVP
RESIDUE RETRIEVAL CONCEPTUAL DESIGN

CIVIL
UTILITY PLAN
STAGE I, II, AND III

| | | | | | |
|---|---|---|---|---|---|
| D. REED | 1-1-96 | L. KUBAN | 3/25/96 | F. PARTON | 1-3-96 |
| | | | SCALE 1"=20' | | |
| | N/A | | | | |

| | | | | | |
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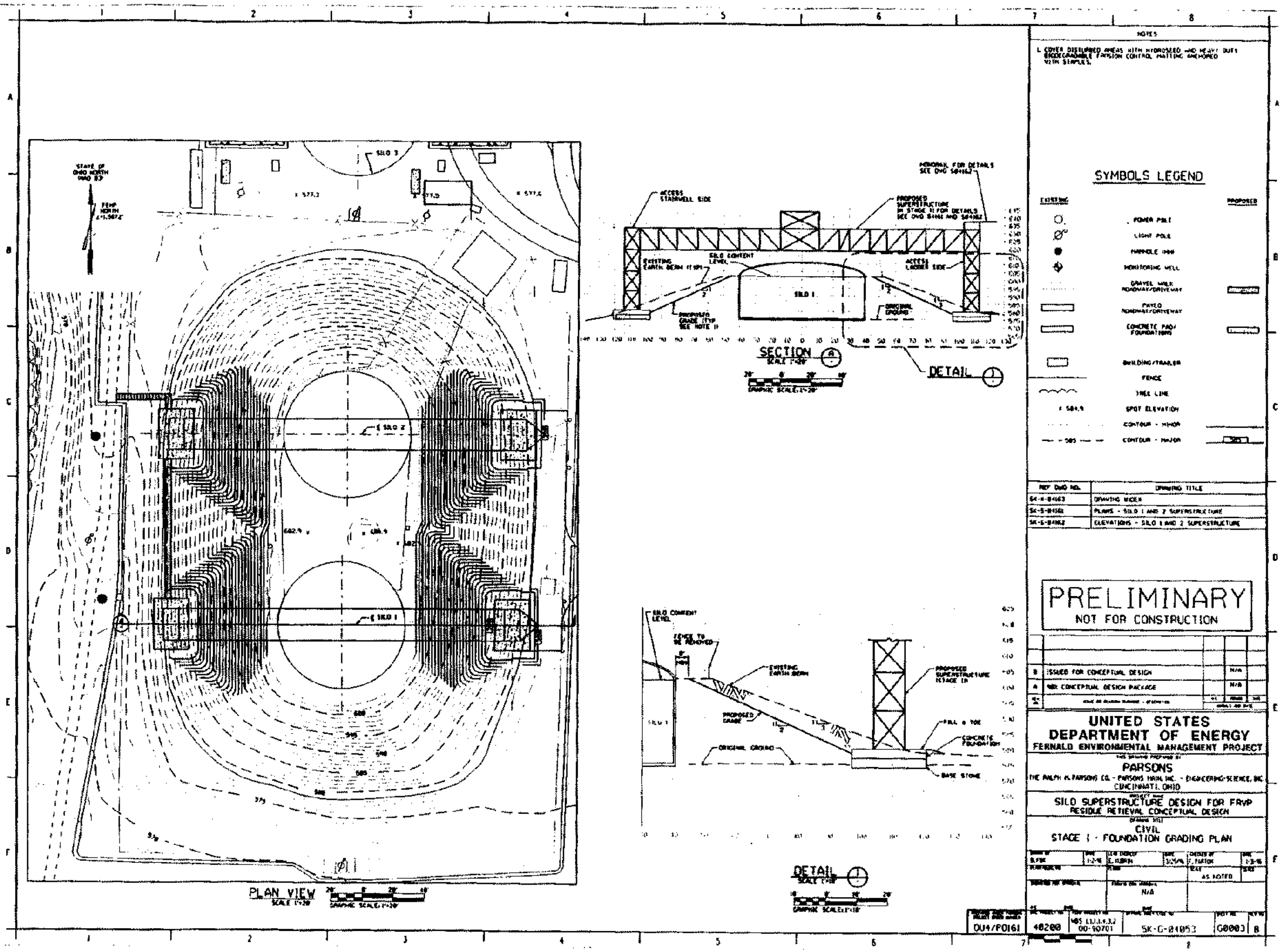
NOTES
1. COVER DISTURBED AREAS WITH HYDROSEED AND HEAVY DUTY BIODEGRADABLE EROSION CONTROL MATTING ANCHORED WITH STAPLES.
SYMBOLS LEGEND
EXISTING
PROPOSED
POWER POLE
LIGHT POLE
MANHOLE
MONITORING WELL
GRAVEL WALK ROADWAY/DRIVEWAY
PAVED ROADWAY/DRIVEWAY
CONCRETE PAD/ FOUNDATIONS
BUILDING/TRAILER
FENCE
TREE LINE
SPOT ELEVATION
CONTOUR - MINOR
CONTOUR - MAJOR
REF DWG NO.
DRAWING TITLE
DRAWING INDEX
PLANS - SILO 1 AND 2 SUPERSTRUCTURE
ELEVATIONS - SILO 1 AND 2 SUPERSTRUCTURE
PRELIMINARY
NOT FOR CONSTRUCTION
ISSUED FOR CONCEPTUAL DESIGN
N/A
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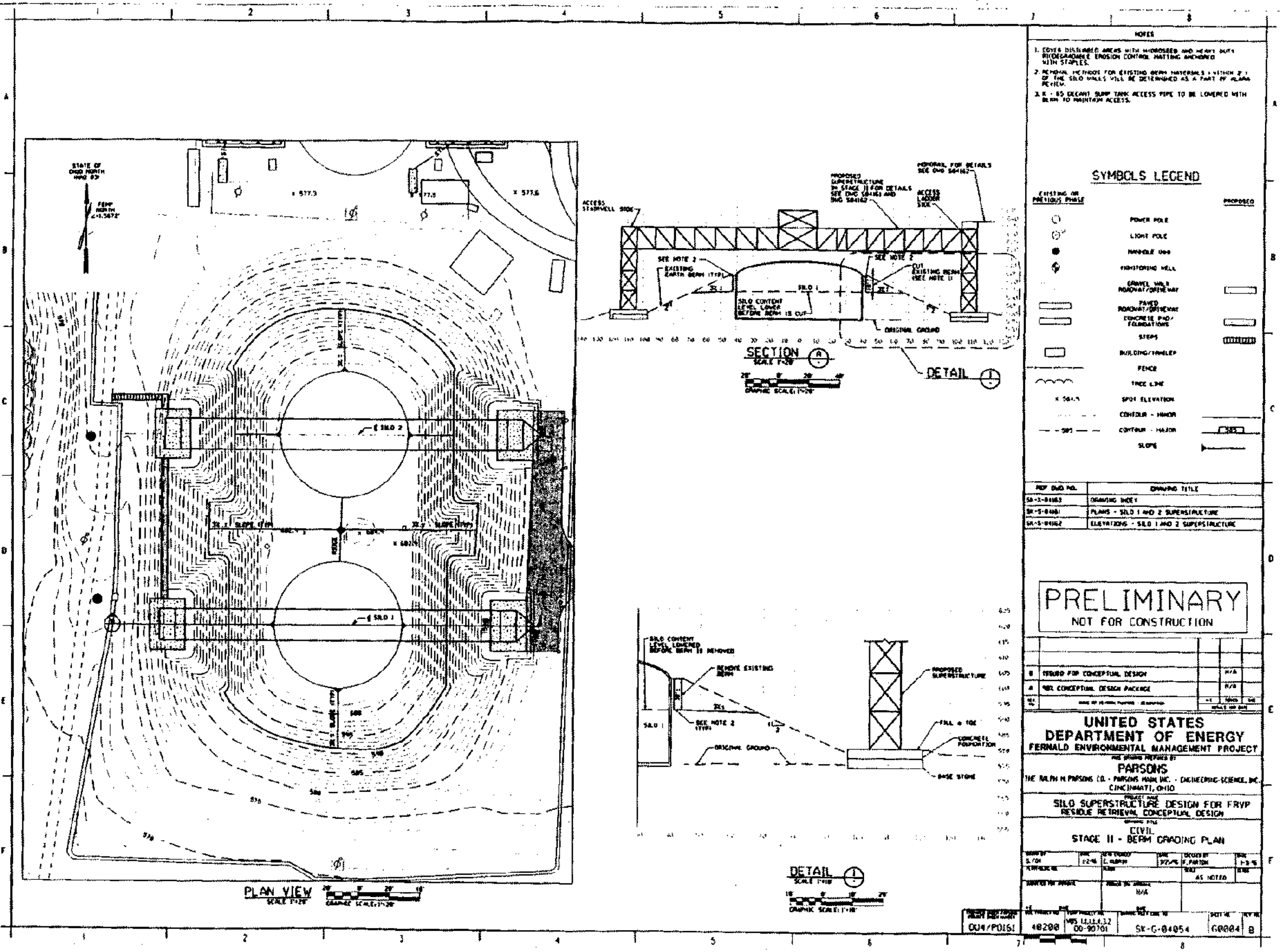
PARSONS
CINCINNATI, OHIO
SILO SUPERSTRUCTURE DESIGN FOR FRVP
RESIDUE RETIEVAL CONCEPTUAL DESIGN
CIVIL
STAGE 1 - FOUNDATION GRADING PLAN
AS NOTED
DU4/PO161
40200
SK-C-04053
G0003
B
SECTION A
DETAIL 1
GRAPHIC SCALE: 1"=20'
SILO 1
SILO 2
SILO 3
ACCESS STAIRWELL SIDE
ACCESS LADDER SIDE
EXISTING EARTH BERM
SILO CONTENT LEVEL
PROPOSED SUPERSTRUCTURE
ORIGINAL GROUND
PROPOSED GRADE
FENCE TO BE REMOVED
CONCRETE FOUNDATION
BASE STONE
PLAN VIEW
SCALE 1"=20'
DETAIL
STATE OF OHIO NORTH
FEMP NORTH


NOTES
1. COVER DISTURBED AREAS WITH HYDROSEED AND HEAVY DUTY BIODEGRADABLE EROSION CONTROL MATTING ANCHORED WITH STAPLES.
3. K - 65 DECANT SUMP TANK ACCESS PIPE TO BE LOWERED WITH BERM TO MAINTAIN ACCESS.
SYMBOLS LEGEND
EXISTING OR PREVIOUS PHASE
PROPOSED
POWER POLE
LIGHT POLE
MANHOLE
MONITORING WELL
PAVED ROADWAY/DRIVEWAY
CONCRETE PAD/ FOUNDATIONS
STEPS
BUILDING/TRAILER
FENCE
TREE LINE
SPOT ELEVATION
CONTOUR - MINOR
CONTOUR - MAJOR
SLOPE
REF DWG NO.
DRAWING TITLE
DRAWING INDEX
PLANS - SILO 1 AND 2 SUPERSTRUCTURE
ELEVATIONS - SILO 1 AND 2 SUPERSTRUCTURE
PRELIMINARY
NOT FOR CONSTRUCTION
ISSUED FOR CONCEPTUAL DESIGN
90% CONCEPTUAL DESIGN PACKAGE
N/A
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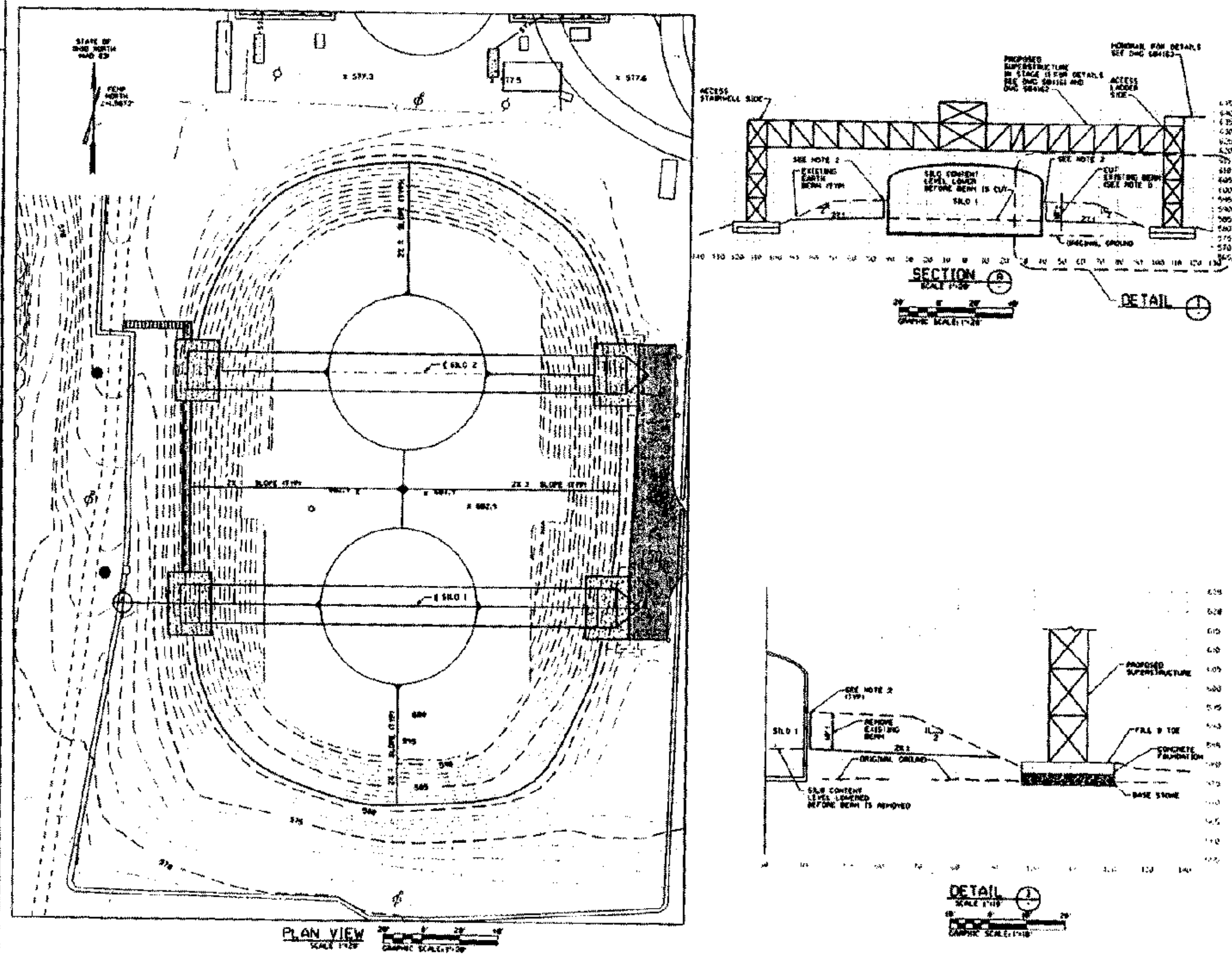
PARSONS
CINCINNATI, OHIO
SILO SUPERSTRUCTURE DESIGN FOR FRVP
RESIDUE RETRIEVAL CONCEPTUAL DESIGN
CIVIL
STAGE II - BERM GRADING PLAN
AS NOTED
004/P0161
40200
00-90701
SK-G-04054
G0004
B
STATE OF OHIO NORTH
FEMP NORTH
x 577.3
x 577.6
SILO 2
SILO 1
RIDGE
SLOPE (TYP)
PLAN VIEW
GRAPHIC SCALE: 1"=20'
ACCESS STAIRWELL SIDE
ACCESS LADDER SIDE
SEE NOTE 2
EXISTING EARTH BERM (TYP)
SILO CONTENT LEVEL LOWER BEFORE BERM IS CUT
CUT EXISTING BERM (SEE NOTE 1)
ORIGINAL GROUND
SECTION A
DETAIL 1
REMOVE EXISTING BERM
SEE NOTE 2 (TYP)
PROPOSED SUPERSTRUCTURE
FILL @ TOE
CONCRETE FOUNDATION
BASE STONE
GRAPHIC SCALE: 1"=10'




**NOTES**

1. COVER DISTURBED AREAS WITH HYDROSEED AND HEAVY DUTY BIODEGRADABLE EROSION CONTROL MATTING ANCHORED WITH STAPLES.
2. REMOVAL METHODS FOR EXISTING BERM MATERIAL CONTAIN... NEAR THE SILO WALLS WILL BE DETERMINED AS A PART OF ALARA REVIEW.
3. K-65 DECANT SUMP TANK ACCESS PIPE TO BE LOWERED WITH BERM TO MAINTAIN ACCESS.

**SYMBOLS LEGEND**

| EXISTING OR PREVIOUS PHASE | | PROPOSED |
|---|---|---|
| | POWER POLE | |
| | LIGHT POLE | |
| | MANHOLE ### | |
| | MONITORING WELL | |
| | GRAVEL WALK ROADWAY/DRIVEWAY | |
| | PAVED ROADWAY/DRIVEWAY | |
| | CONCRETE PAD/FOUNDATIONS | |
| | BUILDING/TRAILER | |
| | STEPS | |
| | FENCE | |
| | TREE LINE | |
| x 583.9 | SPOT ELEVATION | |
| | CONTOUR - MINOR | |
| — 580 — | CONTOUR - MAJOR | |
| | SLOPE | |

| REF DWG NO. | DRAWING TITLE |
|---|---|
| SK-Z-04161 | DRAWING INDEX |
| SK-S-04161 | PLANS - SILO 1 AND 2 SUPERSTRUCTURE |
| SK-S-04162 | ELEVATIONS - SILO 1 AND 2 SUPERSTRUCTURE |

PRELIMINARY
NOT FOR CONSTRUCTION

| REV | | | | |
|---|---|---|---|---|
| A | ISSUED FOR CONCEPTUAL DESIGN | | N/A | |
| A | 90% CONCEPTUAL DESIGN PACKAGE | | N/A | |

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CINCINNATI, OHIO

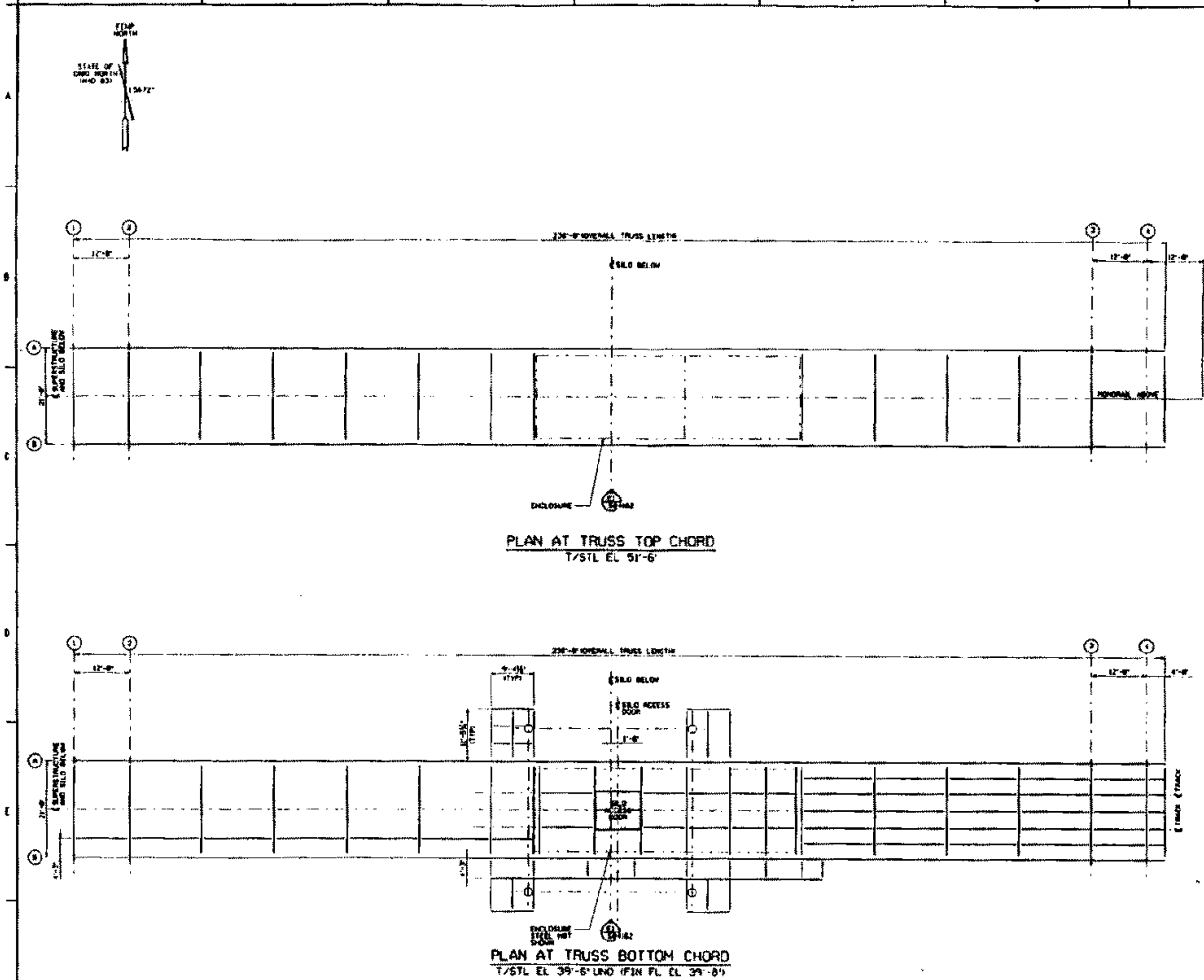
SILO SUPERSTRUCTURE DESIG FOR FRVP RESIDUE RETRIEVAL, CONCEPTUAL DESIGN

CIVIL
STAGE III - BERM GRADING PLAN

SCALE: AS NOTED

OU4/PO161 | 40200 | WBS 1.1.1.4.17 00-90701 | SK-C-04855 | C0005 | B

skg04055.m po161@ws408. Mon Apr 1 15:22:55 CST 1996




PLAN AT TRUSS TOP CHORD
T/STL EL 51'-6"

PLAN AT TRUSS BOTTOM CHORD
T/STL EL 39'-6" UNO (FIN FL EL 39'-8")

GRAPHIC SCALE: 1/8"=1'-0"

NOTES

| REF DWG NO. | DRAWING TITLE |
|---|---|
| SK-S-04163 | DRAWING INDEX |
| SK-S-04162 | ELEVATION - SILO 1 AND 2 SUPERSTRUCTURE |

PRELIMINARY
NOT FOR CONSTRUCTION

| | | |
|---|---|---|
| B | ISSUED FOR CONCEPTUAL DESIGN | N/A |
| A | 90% CONCEPTUAL DESIGN PACKAGE | N/A |

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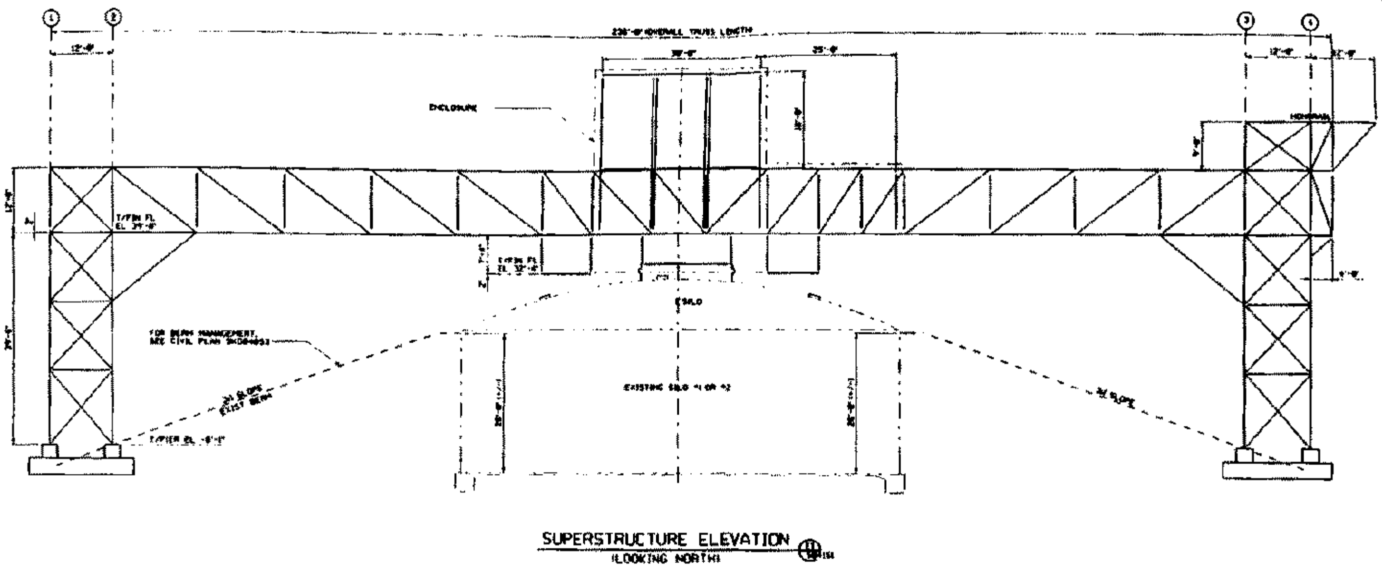
CINCINNATI, OHIO

SILO SUPERSTRUCTURE DESIGN FOR FRVP
RESIDUE RETRIEVAL CONCEPTUAL DESIGN

STRUCTURAL
PLANS
SILO 1 AND 2 SUPERSTRUCTURE

SCALE: 1/8"=1'-0"

DU4/P0161 | 40200 | WBS 1.1.1.1.1.2 00-90701 | SK-S-04161 | S0001 | B




NOTES

| REF DWG NO. | DRAWING TITLE |
| --- | --- |
| SK-X-04163 | DRAWING INDEX |
| SK-X-04161 | PLANS - SILO 1 AND 2 SUPERSTRUCTURE |
| SK-G-04053 | GRADING PLAN |

PRELIMINARY
NOT FOR CONSTRUCTION

| | | |
| --- | --- | --- |
| B | ISSUED FOR CONCEPTUAL DESIGN | N/A |
| A | NRC CONCEPTUAL DESIGN PACKAGE | N/A |

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CINCINNATI, OHIO

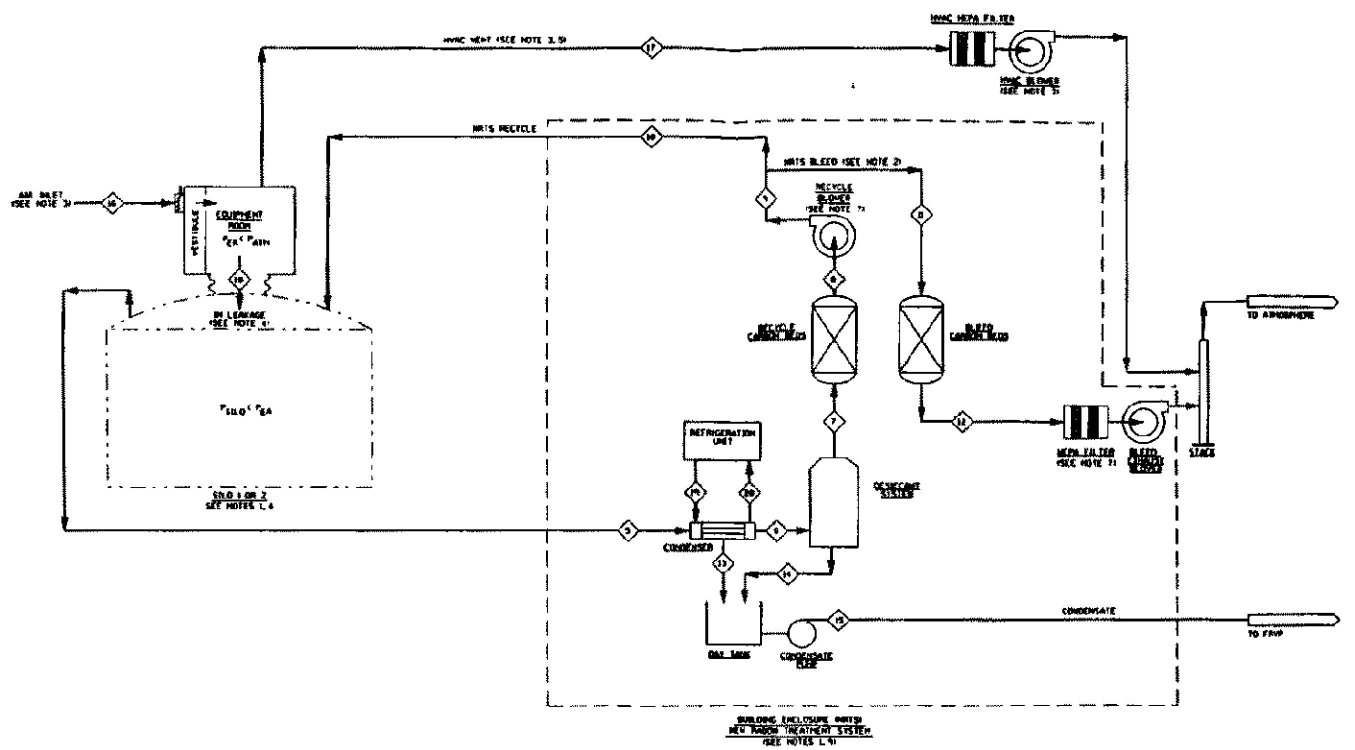
SILO SUPERSTRUCTURE DESIGN FOR FRVP
RESIDUE RETRIEVAL CONCEPTUAL DESIGN

STRUCTURAL
ELEVATION
SILO 1 AND 2 SUPERSTRUCTURE

N/A

OU4/PO161 | 40200 | WBS 1.1.1.1.3.2 00-90701 | SK-S-04162 | 50002 | B

sks04162.m po161@ws318. Thu Mar 28 13:17:46 CST 1996




| STREAM NO. | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COMPONENT | SILO VENT TO CONDENSER | SILO VENT TO DES. TWR | VENT TO CARBON BEDS | VENT TO RECYCLE BLOWER | VENT FR RECYCLE BLOWER | RECYCLE TO SILOS | BLEED TO CARBON BEDS | BLEED FR. CARBON BEDS | CONDEN-SATE | DESICCANT SOLUTION | WATER TO SILO | AIR INLET TO EQUIP. RM. | SILO EQUIP. RM. VENT | AIR FROM ER TO SILO | REFRIG SUPPLY | REFRIG RETURN |
| OPERATING HR/DAY | NOTE 6 | NOTE 6 | NOTE 6 | NOTE 6 | NOTE 6 | NOTE 6 | NOTE 6 | NOTE 6 | NOTE 6 | NOTE 6 | INTERMIT. | | | NOTE 6 | NOTE 6 | NOTE 6 |
| SOLIDS LBS/HR | | | | | | | | | | | | | | | | |
| WATER - GAS LBS/HR | | | | | | | | | | | | | | | | |
| WATER - LIQUID LBS/HR | | | | | | | | | 58 | | | | | | | |
| DRY AIR LBS/HR | | | | | | | | | | | | | | | | |
| TOTAL LBS/HR | | | | | | | | | 59 | | | | | | | |
| SPECIFIC GRAVITY | | | | | | | | | | | | | | | | |
| DENSITY - AIR (LBS/CU.FT.) | | | | | | | | | | | | | | | | |
| TEMPERATURE (DEG. F) | 70 | | | | | | | | | | | | | | | |
| GAS FLOW (SCFM) | 1000 | | 1000 | 1000 | 750 | 750 | 250 | 250 | | | | | | 250 | | |
| PRESSURE (INCHES W.G.) | | | | | | | | | | | | | | | | |
| RADON CONCENTRATION (pCi/L) | | | | | | | | | | | | | | | | |
| NOTES | 1, 4, 9 | | 9 | 9 | 9 | 9 | 2, 9 | 9 | 9 | | | | 3, 5 | 9 | | |

NOTES

1. THIS SKETCH SHOWS EACH K-65 SILO WITH AN INDEPENDENT RADON TREATMENT SYSTEM. A COMBINED NRTS TO TREAT BOTH SILOS MAY BE USED AS AN ALTERNATIVE.
2. BLEED FLOW WILL BE CONTROLLED TO MAINTAIN NEGATIVE PRESSURE IN THE SILO RELATIVE TO THE EQUIPMENT ROOM.
3. AIR INLET IN EQUIPMENT ROOM WILL BE CONTROLLED TO MAINTAIN A PRESET NEGATIVE PRESSURE IN EQUIPMENT ROOM, RELATIVE TO THE ATMOSPHERE.
4. MINIMAL NRTS FLOWRATE WILL BE OBTAINED BY MINIMIZING THE OPENING BETWEEN THE EQUIPMENT ROOM AND THE SILO HEADSPACE.
5. THE HVAC SYSTEM WILL BE USED TO CONTROL TEMPERATURE AND PRESSURE IN THE EQUIPMENT ROOM.
6. OPERATING TIME OF THE NRTS WILL BE DETERMINED DURING DETAILED DESIGN OF NRTS.
7. SPARE HEPA FILTERS/BLOWERS WILL BE INCLUDED IN THE DETAILED DESIGN.
8. ALL LINES TO BE LOCATED ABOVE GRADE IN PIPE RACK.
9. NRTS EQUIPMENT AND FLOWRATES ARE PRELIMINARY AND ARE SHOWN FOR INFORMATION ONLY.

| REF DWG NO. | DRAWING TITLE |
|---|---|
| SK-X-B4163 | DRAWING INDEX |

PRELIMINARY
NOT FOR CONSTRUCTION

| REV | DESCRIPTION | |
|---|---|---|
| B | ISSUED FOR CONCEPTUAL DESIGN | N/A |
| A | 90% CONCEPTUAL DESIGN PACKAGE | N/A |

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FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

PARSONS
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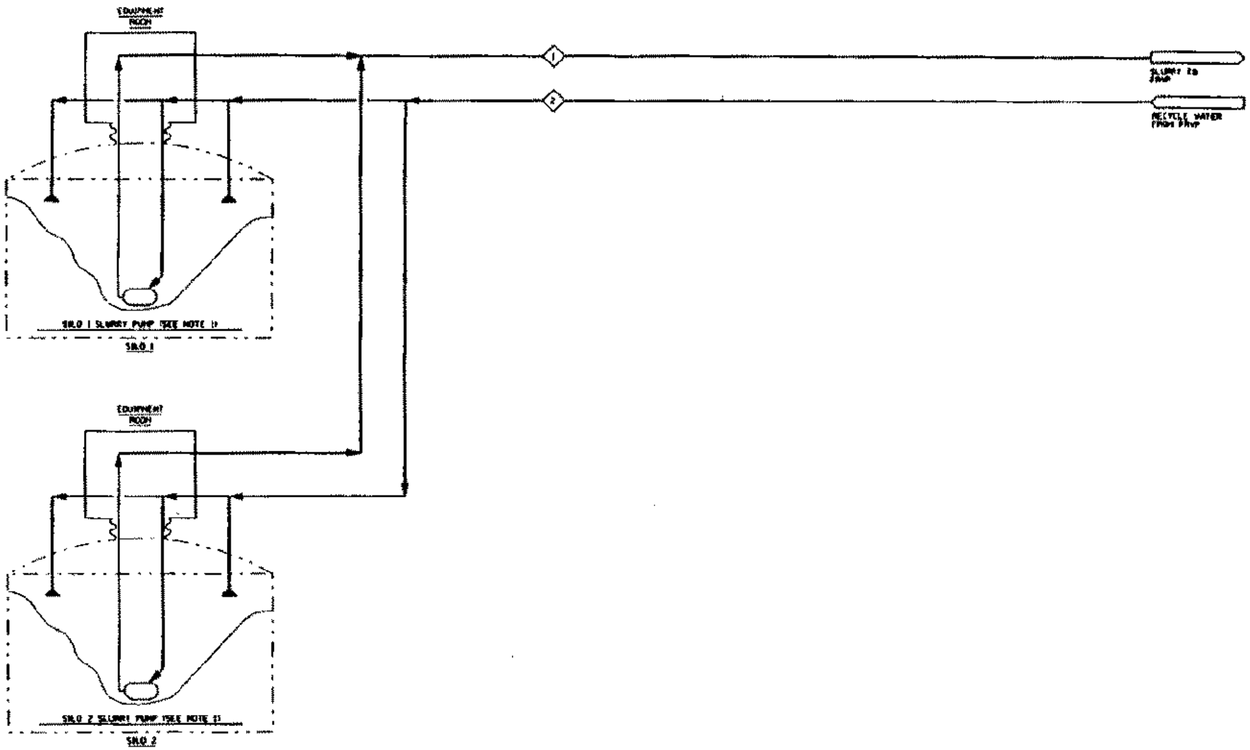
CINCINNATI, OHIO

SILO SUPERSTRUCTURE DESIGN FOR FRVP
RESIDUE RETRIEVAL CONCEPTUAL DESIGN

PROCESS
PROCESS FLOW DIAGRAM
NEW RADON TREATMENT SYSTEM & EQUIPMENT ROOM HVAC

SCALE: NONE
N/A

DU4/P0161 | 40200 | WBS 1.1.1.1.4.3.2 00-90701 | SK-F-04075 | F0001 | B




| STREAM NO. | 1 | 2 |
|---|---|---|
| COMPONENT | SLURRY TO FRVP | RECYCLE WTR FROM FRVP |
| OPERATING HR/DAY | [illegible] | [illegible] |
| SOLIDS LBS/HR | [illegible] | NEG. |
| WATER - GAS LBS/HR | | |
| WATER - LIQUID LBS/HR | [illegible] | [illegible] |
| DRY AIR LBS/HR | | |
| TOTAL LBS/HR | [illegible] | [illegible] |
| | | |
| SPECIFIC GRAVITY - DRY SOLIDS | [illegible] | |
| % MOISTURE IN SOLIDS | [illegible] | |
| SPECIFIC GRAVITY - SLURRY | 1.15 | |
| | | |
| PERCENT SOLIDS - SLURRY | 20 | NEG. |
| TEMPERATURE (DEG F) | | |
| LIQUID FLOW (GPM) | 140 | [illegible] |
| NOTES | 1, 2, 4 | 3, 4 |

NOTES

1. EACH K-65 SILO HAS A SEPARATE AND COMPLETE RESIDUE REMOVAL SYSTEM HOWEVER, RESIDUE WILL ONLY BE REMOVED FROM ONE SILO AT A TIME.
2. ASSUME SOLIDS CONTAIN [illegible]% MOISTURE.
3. FLOWS BASED ON K-65 ONLY FORMULATION USING [illegible] K-65 PER [illegible] GLASS.
4. FLOW RATES AND OPERATING TIME/DAY WILL VARY BASED ON ACTUAL SYSTEM CHARACTERISTICS AND ACHIEVABLE PERCENT SOLIDS IN SLURRY.
5. ALL PIPING TO BE LOCATED ON SUPERSTRUCTURE AND ABOVE GRADE IN PIPE RACK.

| REF DWG NO. | DRAWING TITLE |
|---|---|
| SK-X-04163 | DRAWING INDEX |

PRELIMINARY
NOT FOR CONSTRUCTION

| | | |
|---|---|---|
| B | ISSUED FOR CONCEPTUAL DESIGN | N/A |
| A | 90% CONCEPTUAL DESIGN PACKAGE | N/A |

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CINCINNATI, OHIO

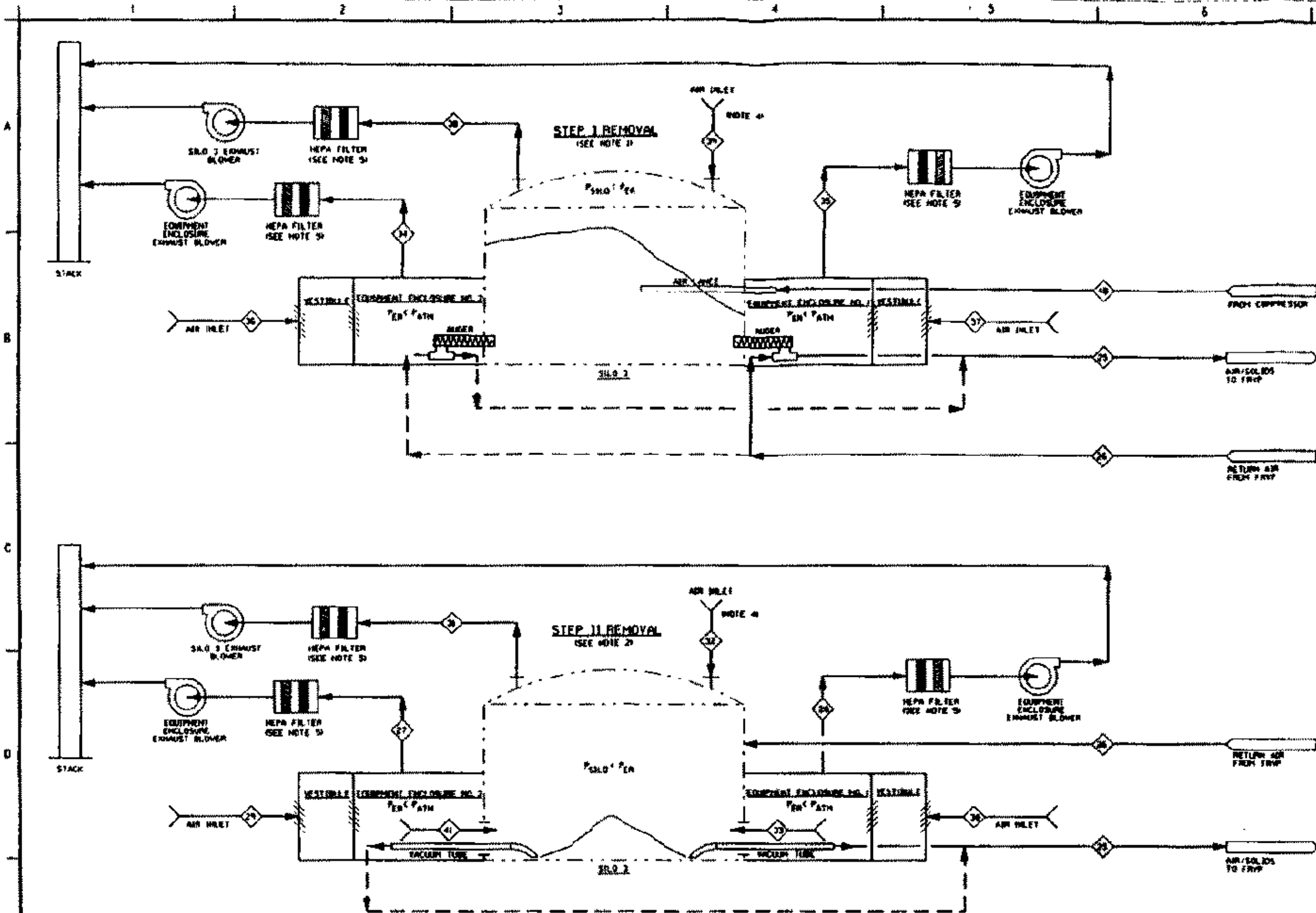
SILO SUPERSTRUCTURE DESIGN FOR FRVP
RESIDUE RETRIEVAL CONCEPTUAL DESIGN

PROCESS
PROCESS FLOW DIAGRAM
HYDRAULIC RETRIEVAL, SILO 1 & 2

N/A
NONE

OU4/PO161 | 40200 | WBS [illegible] | SK-F-04076 | F0002 | B

skf04076.m po161@ws306. Fri Mar 29 13:58:46 CST 1996




NOTES

1. STEP 1 WILL UTILIZE 2 AUGER SYSTEMS TO REMOVE SOLIDS FROM SILO 3. ONLY ONE AUGER SYSTEM WILL BE OPERATED AT ONE TIME.
2. STEP 2 WILL UTILIZE VACUUM TUBE PNEUMATIC CONVEYING SYSTEMS TO REMOVE THE REMAINING SOLIDS FROM SILO 3 FOLLOWING THE AUGER REMOVAL. THE PNEUMATIC SYSTEM WILL HAVE ACCESS FROM BOTH EQUIPMENT ENCLOSURES. ONLY ONE SYSTEM WILL BE OPERATED AT ONE TIME.
3. OPERATING HR/DAY ASSUMES GLASS FORMULATION USING 18.54 LB SILO 3 SOLIDS PLUS 4.45 SOLIDS PLUS ADDITIVES PER 100LB GLASS. ALTERNATE GLASS FORMULATIONS MAY REQUIRE ADDITIONAL TRANSFER TIME FOR SILO 3 MATERIAL.
4. VACUUM BREAK PREVENTS EXCESSIVE NEGATIVE SILO AIR PRESSURE.
5. OPERATIONAL SPARES WILL BE PROVIDED FOR HEPA UNITS.
6. HVAC FLOWS ARE ESTIMATES PENDING DETAILED DESIGN. FLOWS ARE USED FOR PRELIMINARY SIZING OF EQUIPMENT.

| STREAM NO. | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COMPONENT | SILO 3 SOLIDS TO FRVP | AIR RETURN FR. FRVP | EN NO. 2 VENT | EN NO. 1 VENT | EN NO. 2 AIR INLET | EN NO. 1 AIR INLET | SILO VENT | AIR INLET TO SILO | AIR INLET TO SILO | EN NO. 2 VENT | EN NO. 1 VENT | EN NO. 2 AIR INLET | EN NO. 1 AIR INLET | SILO VENT | AIR INLET TO SILO | AIR TO LANCE | AIR INLET TO SILO |
| OPERATING HR/DAY | 24 | | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | INTERMIT | 24 |
| SOLIDS (LBS/HR) | 4000 | | | | | | | | | | | | | | | | |
| WATER GAS (LBS/HR) | 24 | | | | | | | | | | | | | | | | |
| DRY AIR (LBS/HR) | 1534 | | | | | | | | | | | | | | | | |
| TOTAL (LBS/HR) | 5558 | | | | | | | | | | | | | | | | |
| SPECIFIC GRAVITY - DRY SOLIDS | 2.32 | | | | | | | | | | | | | | | | |
| BULK DENSITY (LBS/CU.FT.) | 54.9 | | | | | | | | | | | | | | | | |
| PERCENT MOISTURE - SOLIDS | 1.9 | | | | | | | | | | | | | | | | |
| DENSITY - AIR (LBS/CU.FT.) | | | | | | | | | | | | | | | | | |
| TEMPERATURE (DEG F) | 70 | | | | | | | | | | | | | | | | |
| PRESSURE (INCHES W.G.) | | | | | | | | | | | | | | | | | |
| GAS FLOW (SCFM) | 350 | | <2000 | <2000 | <2000 | <2000 | <1000 | | <200 | <2000 | <2000 | <2000 | <2000 | <1000 | | | <200 |
| NOTES | 3 | | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | | 6 |

| REF DWG NO. | DRAWING TITLE |
|---|---|
| SK-X-04103 | DRAWING INDEX |

PRELIMINARY
NOT FOR CONSTRUCTION

| REV | DESCRIPTION | |
|---|---|---|
| B | ISSUED FOR CONCEPTUAL DESIGN | N/A |
| A | 90% CONCEPTUAL DESIGN PACKAGE | N/A |

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

THIS DRAWING PREPARED BY
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CINCINNATI, OHIO

SILO SUPERSTRUCTURE DESIGN FOR FRVP
RESIDUE RETRIEVAL CONCEPTUAL DESIGN

PROCESS
PROCESS FLOW DIAGRAM
PNEUMATIC RETRIEVAL SILO 3

SCALE: NONE

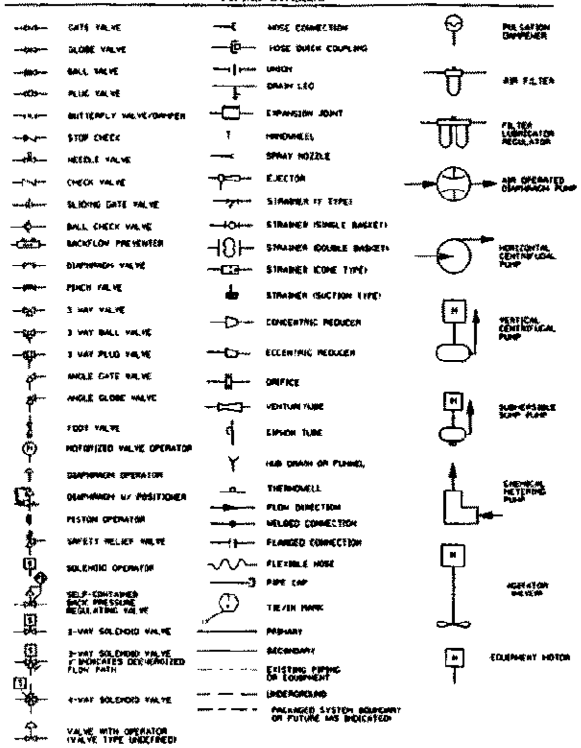
OU4/PO161 | 40200 | WBS 1.1.6.1.3.2 00-90701 | SK-F-04077 | F0003 | B

skf04077.m po161@ws306. Mon Apr 1 15:07:28 CST 1996 skn04219.m pdsgen@ws306. Thu Mar 28 12:08:35 CST 1996

NOTES

1. SECONDARY CONTAINMENT IS REQUIRED FOR FLOWING MEDIUM WITH MATERIAL CODE DESIGNATED BY * *.

## PIPING SYMBOLS




## ABBREVIATIONS

| | |
|---|---|
| BTU | BRITISH THERMAL UNIT |
| CU FT | CUBIC FEET |
| GPH | GALLONS PER HOUR |
| GPM | GALLONS PER MINUTE |
| KW | KILOWATT |
| LB/HR | POUNDS PER HOUR |
| SCFM | STD. CUBIC FT/MINUTE |
| NO | NORMALLY OPEN |
| NC | NORMALLY CLOSED |
| FO | FAIL OPEN |
| FC | FAIL CLOSED |
| AO | AIR TO OPEN |
| AC | AIR TO CLOSE |
| IA | INSTRUMENT AIR |
| ET | ELECTRIC TRACED AND INSULATED |
| ST | STEAM TRACED AND INSULATED |
| EF | EXHAUST FAN |
| GV | GRAVITY VENTILATOR |
| UH | UNIT HEATER |
| RED | REDUCER |
| ECC | ECCENTRIC |
| TBD | TO BE DETERMINED |
| TF | TOP FLAT |
| TYP | TYPICAL |
| MATL | MATERIAL |
| MED | MEDIUM |
| CO | CARBON MONOXIDE |
| RH | RELATIVE HUMIDITY |
| CFM | CUBIC FEET/MINUTE |
| I | INSULATION |
| P | PERSONNEL PROTECTION |

## INSTRUMENTATION SPECIAL DESIGNATIONS

| DESIGNATION | FUNCTION/ABBREVIATION |
|---|---|
| Σ/N OR AVG | AVERAGING |
| ± OR BI | BIAS |
| 1:1, 1:2, 2:1 (TYP) | BOOST, GAIN OR ATTENUATE (INPUT:OUTPUT) |
| Δ OR DIF | DIFFERENTIAL |
| ÷ OR DIV | DIVIDE |
| √ OR SQRT. | EXTRACT SQUARE ROOT |
| X OR MUL | MULTIPLY |
| $x^n$ | RAISE TO POWER |
| REV | REVERSING |
| Σ OR SUM | SUMMING |
| L | LOW |
| LL | LOW LOW |
| H | HIGH |
| HH | HIGH HIGH |
| HL | HIGH LOW |
| ∫ | INTEGRATE (TIME INTEGRAL) |
| K | PROPORTIONAL |
| F | UNDETERMINED COMPUTING RELAY |
| HOA | HAND-OFF-AUTO |
| ** | EXISTING INSTRUMENT TO BE RELOCATED |
| I/P | CURRENT TO PNEUMATIC TRANSDUCER |
| RUN | RUNNING |
| OA | OFF-AUTO |
| OCA | OPEN-CLOSE-AUTO |
| I/O | INPUT / OUTPUT |
| * | EXISTING INSTRUMENT |
| UD | UP/DOWN |
| EW | EAST/WEST |
| I/I | CURRENT TO CURRENT |
| ' | INST. PROVIDED WITH ASSOCIATED EQUIP. |

## PIPING SPECIFICATIONS

| FLOWING MEDIUM | MED CODE | MAT'L CODE |
|---|---|---|
| BACK WASH | BW | A |
| BREATHING AIR | BA | A5 |
| CHILLED WATER | CHS, CHR | A |
| CHLORINE | CL | B1 |
| CONDENSATE | LC | A |
| CONDENSER WATER | CWS, CWR | A |
| COOLING WATER | WS, WR | A |
| DRAIN | DR | A |
| THICKENER OVERFLOW | TO | A |
| FILTRATE EFFLUENT | FT | A |
| FLOCCULANT | FL | A |
| FLUSH WATER | FW | A |
| FORCE MAIN | FM | M |
| INSTRUMENT AIR | IA | W |
| MELTER OFF-GAS | OG | T, A |
| NITRIC ACID | AN | T1 |
| PERCHED GND WATER | PGW | B |
| PHOSPHORIC ACID | PAPH | T1 |
| PLANT AIR | PA | A |
| POLISHED WATER | PW | A |
| POTABLE WATER | DW | W, B |
| PROCESS WATER | TV | W |
| PROCESS WASTEWATER | CT | A |
| RAW WATER | RW | A |
| RECYCLE WATER | RC | A, A2 * * |
| SCRUBBER RECYCLE | RSL | T |
| SLURRY | SL | A * * |
| SLURRY ADDITIVE | SA | A1 |
| SODIUM HYDROXIDE | NH | A |
| SODIUM SILICATE | SS | A |
| STORM WATER | ST | A |
| SULFURIC ACID | SA | T1 |
| SUMP DISCHARGE | SD | A |
| VACUUM | V | A |
| VENT | VT | A, T3 |
| WASTE WATER | WW | A |

EXAMPLE:

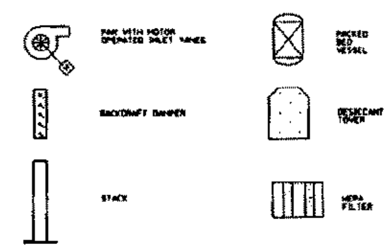
CE-2"-A-100-ET

MEDIUM CODE
NOMINAL PIPE SIZE
MATERIAL CODE
LINE NUMBER
HEAT TRACING AND INSULATION

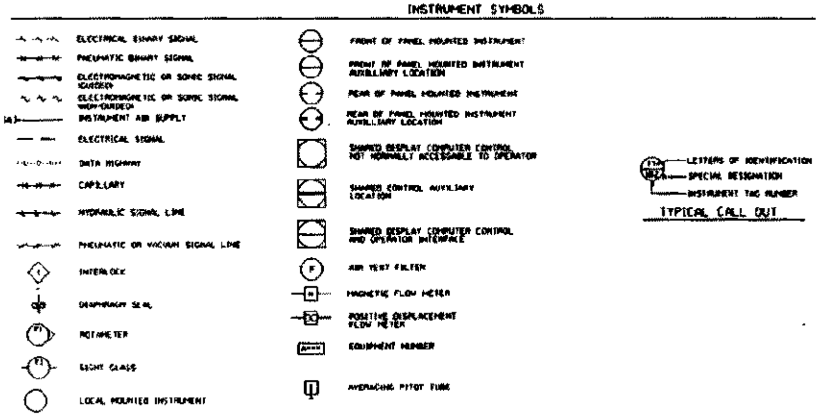
A - CLASS 150, CARBON STEEL
A1 - CLASS 150, CARBON STEEL
A2 - CLASS 300, CARBON STEEL
A3 - CLASS 150, CARBON STEEL
B - CLASS 150, PVC
B1 - PVDF
B2 - PVDF, 100 PSI
B3 - CLASS 150, CPVC
L - CLASS 150, FRP
M - CLASS 125, DUCTILE IRON
T - CLASS 150, 304L STAINLESS STEEL
T1 - CLASS 150, 316L STAINLESS STEEL
T2 - CLASS 300, 304L STAINLESS STEEL
T3 - CLASS 150, 304L STAINLESS STEEL
W - CLASS 150, GALVANIZED CARBON STEEL

* * SEE NOTE 1

## HVAC SYMBOLS




## INSTRUMENT SYMBOLS




## LETTERS OF INSTRUMENT IDENTIFICATION

| LETTER | FIRST LETTER | 2ND LETTER | 3RD OR 4TH LETTER |
|---|---|---|---|
| | MEASURED OR INITIATING VARIABLE | MODIFIER | READ OUT OR PASSIVE FUNCTION |
| A | ANALYSIS | ALARM | ALARM |
| B | BURNER FLAME | ---- | ---- |
| C | CAMERA | CONTROLLER | CONTROLLER |
| D | DENSITY | DIFFERENTIAL | ---- |
| E | VOLTAGE | ELEMENT | ELEMENT |
| F | FLOW RATE | RATIO (FRACTION) | ---- |
| G | GAGING (DIM) | VIEWING DEVICE | GLASS |
| H | HAND (MANUAL) | ---- | HIGH |
| I | CURRENT (ELECT) | INDICATE | INDICATE |
| J | POWER | SCAN | ---- |
| K | TIME | ---- | ---- |
| L | LEVEL | LIGHT | LOW |
| M | MOIST. OR HUMIDITY | ---- | ---- |
| N | ---- | ---- | ---- |
| O | OBSERVATION | ---- | ORIFICE |
| P | PRESSURE OR VACUUM | ---- | POINT (TEST) |
| Q | QUANTITY OF EVENT | TOTALIZER | ---- |
| R | RADIOACTIVITY | RECORDER | RECORDER |
| S | SPEED OR FREQUENCY | SAFETY/SWITCH | SWITCH |
| T | TEMPERATURE | TRANSMITTER | TRANSMITTER |
| U | USER'S CHOICE | ---- | MULTIFUNCTION |
| V | VISCOSITY | ---- | VENT, VALVE |
| W | WEIGHT OR FORCE | WELL | ---- |
| X | UNCLASSIFIED | ---- | UNCLASSIFIED |
| Y | RELAY | RELAY | ---- |
| Z | POSITION | ---- | ---- |

| REF DWG NO. | DRAWING TITLE |
|---|---|
| SK-N-04463 | DRAWING INDEX |
| SK-N-04220 | HYDRAULIC RETRIEVAL, SILO 1 & 2 P&ID |
| SK-N-04296 | SILO 3 MATERIAL RETRIEVAL SYSTEM P&ID |

PRELIMINARY
NOT FOR CONSTRUCTION

| | | |
|---|---|---|
| B | ISSUED FOR CONCEPTUAL DESIGN | N/A |
| A | 90% CONCEPTUAL DESIGN PACKAGE | N/A |

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PARSONS
THE RALPH M. PARSONS CO. · PARSONS MAIN INC. · ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

SILO SUPERSTRUCTURE DESIGN FOR FRVP RESIDUE RETRIEVAL CONCEPTUAL DESIGN

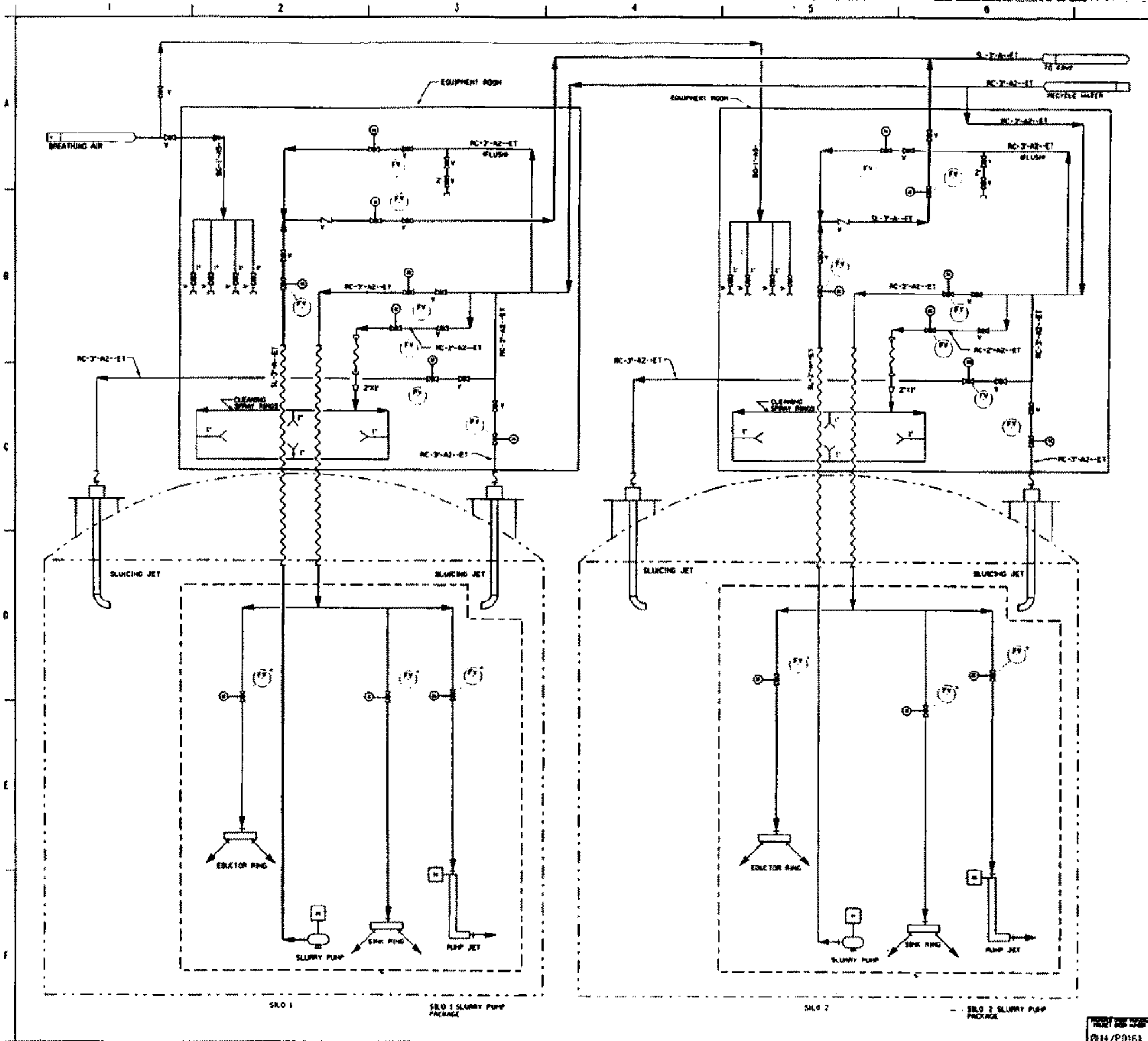
MECHANICAL PROCESS
PIPING AND INSTRUMENTATION DIAGRAM
SYMBOLS AND LEGEND SHEET

P.A. WILSON 1/5/96 · SALIM GHANTOUS 3/7/96 · KAREN ADAMS 3/6/96

SCALE: NONE

N/A

0U4/P0161 | 40200 | WBS 1.1.1.1.4.12 00-90701 | SK-N-04219 | N0001 | B




NOTES

1. PIPING SIZES BASED ON PRELIMINARY FLOWS. ACTUAL SIZING TO BE CONFIRMED/ADJUSTED DURING TITLE DESIGN.
2. DETAILED DESIGN OF HYDRAULIC RETRIEVAL AND SYSTEM MONITORING REQUIREMENTS WILL CONSIDER INTEGRATION/USE OF, OR REPLACEMENT OF EXISTING DATA LOGGING SYSTEM INSTRUMENTATION.

| REF DWG NO. | DRAWING TITLE |
|---|---|
| SK-I-04463 | DRAWING INDEX |
| SK-N-04219 | SYMBOLS AND LEGEND SHEET |

PRELIMINARY
NOT FOR CONSTRUCTION

| | | |
|---|---|---|
| B | ISSUED FOR CONCEPTUAL DESIGN | N/A |
| A | 90% CONCEPTUAL DESIGN PACKAGE | N/A |

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

PARSONS
THE RALPH M. PARSONS CO. - PARSONS MAIN, INC. - ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

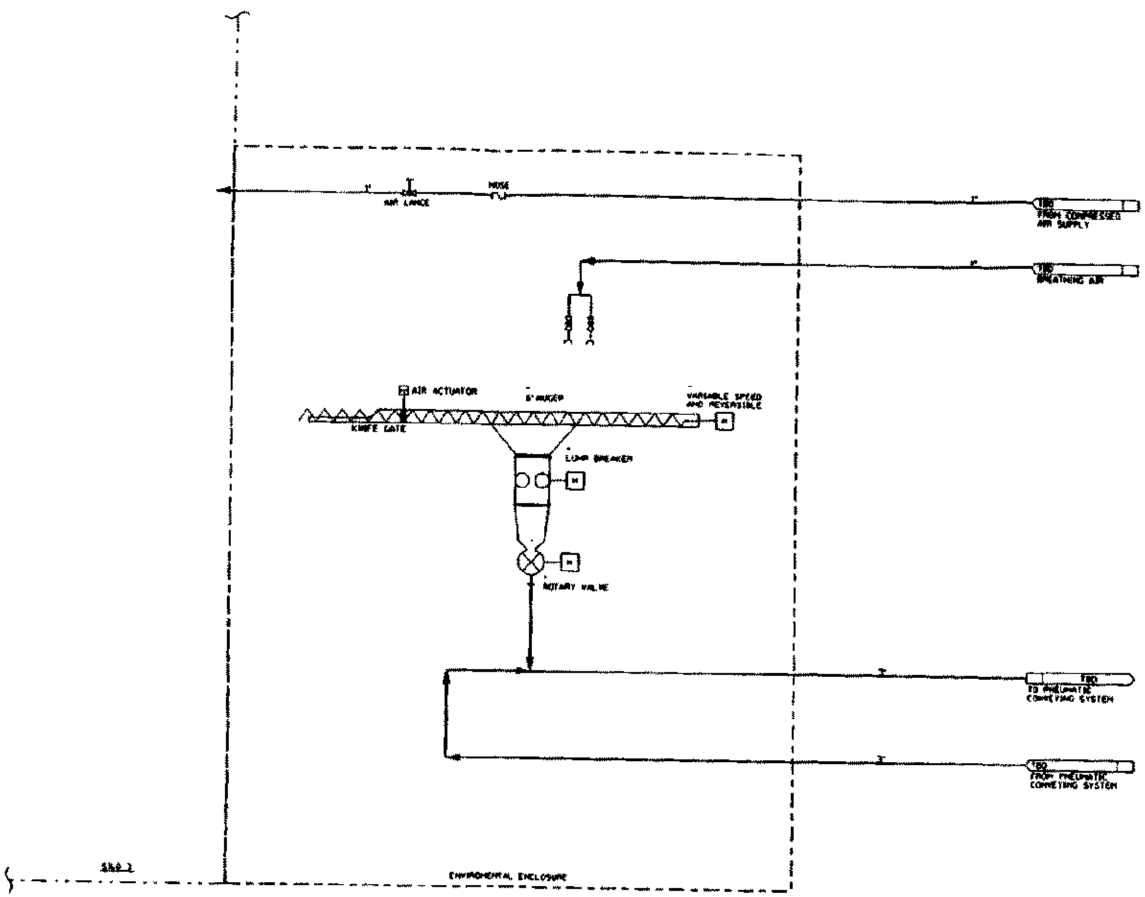
SILO SUPERSTRUCTURE DESIGN FOR FRVP
RESIDUE RETRIEVAL CONCEPTUAL DESIGN

MECHANICAL PROCESS
PIPING AND INSTRUMENTATION DIAGRAM
HYDRAULIC RETRIEVAL, SILO 1 & 2

SCALE: NONE

N/A

0U4/P0161 | 40208 | WBS 1.1.14.4.3.2 00-90701 | SK-N-04220 | N0002 | B




NOTES

1. PIPING LINE SIZES ARE BASED ON PRELIMINARY INFORMATION.

| REF DWG NO. | DRAWING TITLE |
|---|---|
| SK-N-04163 | DRAWING INDEX |
| SK-N-04296 | SYMBOLS AND LEGEND SHEET |

PRELIMINARY

NOT FOR CONSTRUCTION

A | ISSUED FOR CONCEPTUAL DESIGN | N/A

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DEPARTMENT OF ENERGY

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

PARSONS

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CINCINNATI, OHIO

SILO SUPERSTRUCTURE DESIGN FOR FRVP RESIDUE RETRIEVAL CONCEPTUAL DESIGN

MATERIALS HANDLING

EQUIPMENT AND INSTRUMENTATION DIAGRAM

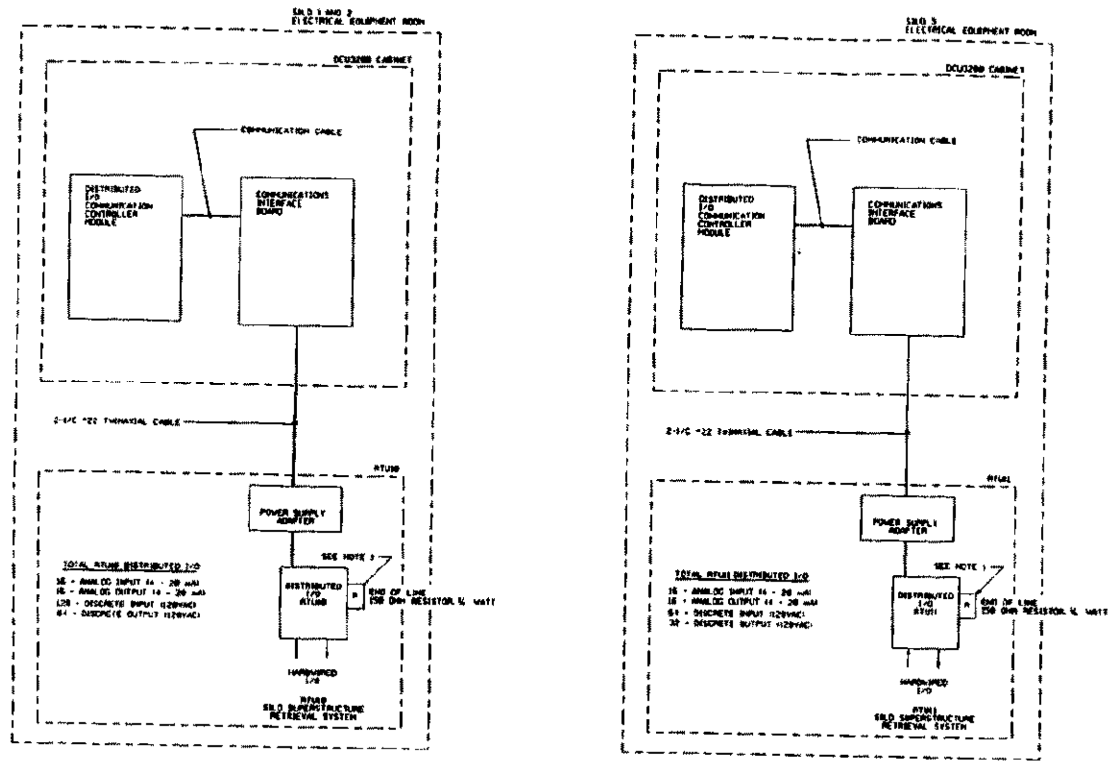
SILO 3 MATERIAL RETRIEVAL SYSTEM

J. OTER | J. COOPER | J. COOPER

N/A

DU4/PO161 | 40200 | WBS 1.1.1.4.3.2 00-90701 | SK-N-04296 | N0003 | A

skn04296.m pdsgen@ws405. Mon Apr 1 15:26:24 CST 1996




NOTES

1. PROVIDE 150 OHM RESISTOR AND CONNECT TO THE LAST DISTRIBUTED I/O CARDS OUTGOING COMMUNICATION TERMINAL.
2. UNDER DIRECTION OF THE FERMCO CONSTRUCTION MANAGER, INSTALL COMPONENTS AS SHOWN INSIDE THE DCU3200 CABINET.
3. CONCEPTUAL DESIGN BASED ON A FISCHER & PORTER DISTRIBUTED CONTROL SYSTEM, WITH I/O COUNT DETERMINED BY THE MINIMUM NUMBER OF INPUTS FROM THE ASSOCIATED P&ID'S IN THIS CONCEPTUAL DESIGN. INPUT AND OUTPUT CARDS WILL HAVE A NOMINAL 8 OR 16 INPUTS/OUTPUTS PER I/O CARD.

| REF SHEET NO. | DRAWING TITLE |
|---|---|
| SK-X-04183 | DRAWING INDEX |

PRELIMINARY
NOT FOR CONSTRUCTION

A ISSUED FOR CONCEPTUAL DESIGN N/A

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

PARSONS
THE RALPH M. PARSONS CO. - PARSONS MAIN INC. - ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

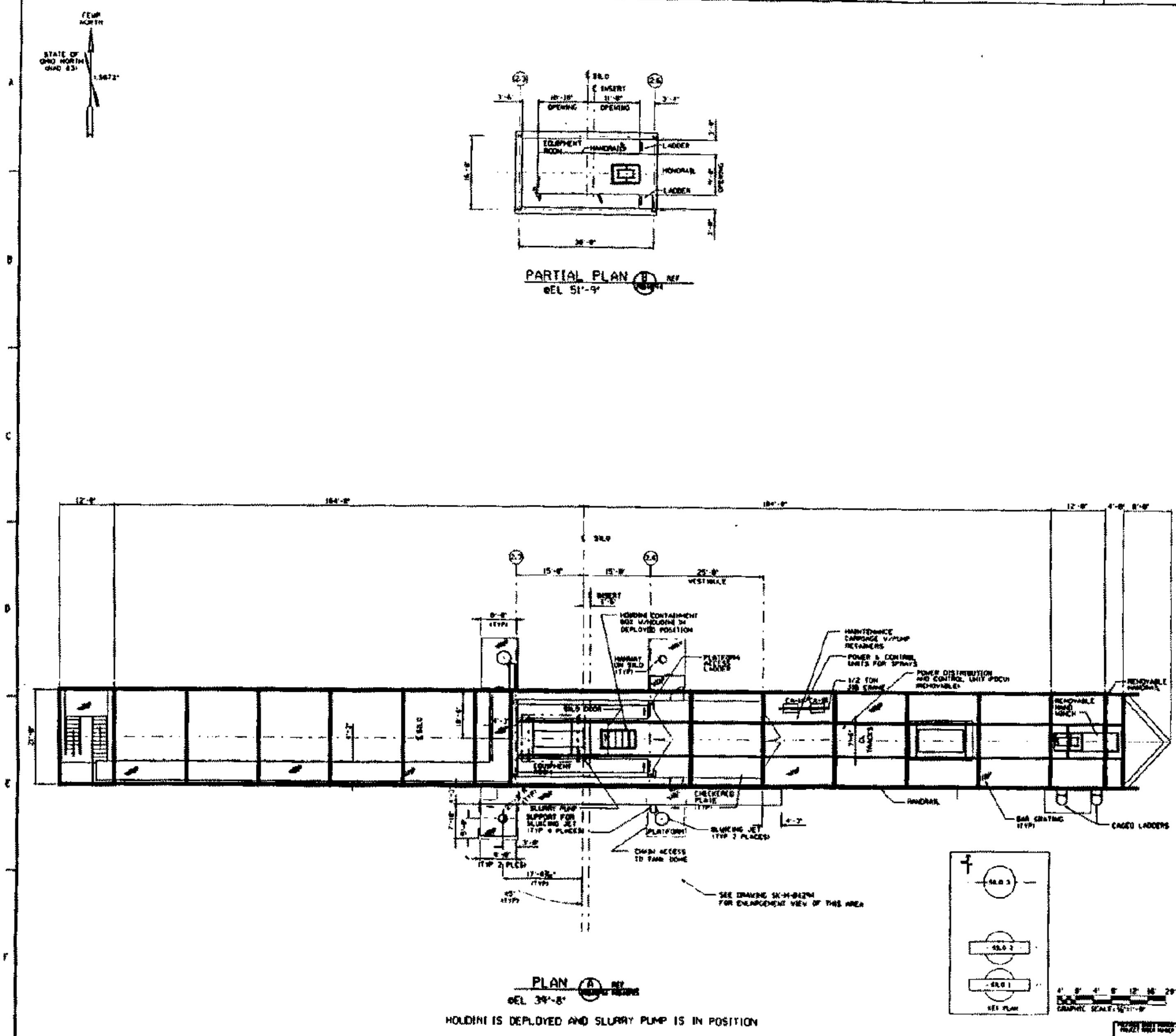
SILO SUPERSTRUCTURE DESIGN FOR FRVP RESIDUE RETRIEVAL CONCEPTUAL DESIGN

INSTRUMENTATION
CONTROL SYSTEM ARCHITECTURE DRAWING
SHEET 1

SCALE: NONE
N/A

0U4/P0161 | 40200 | WBS 1.1.1.1.4.3.2 00-90701 | SK-N-04295 | N0004 | A

skn04295.m po161@ws315. Thu Mar 28 09:27:54 CST 1996




NOTES

| REF DWG NO. | DRAWING TITLE |
|---|---|
| SK-M-84163 | DRAWING INDEX |
| SK-M-84095 | HYDRAULIC RETRIEVAL SILO 1 & 2 - ELEVATION |
| SK-S-804162 | PLAN - SILO 1 & 2 SUPERSTRUCTURE |
| SK-M-84294 | PARTIAL PLAN |

PRELIMINARY
NOT FOR CONSTRUCTION

| | |
|---|---|
| B | ISSUED FOR CONCEPTUAL DESIGN |
| A | 90% CONCEPTUAL DESIGN PACKAGE |

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

PARSONS
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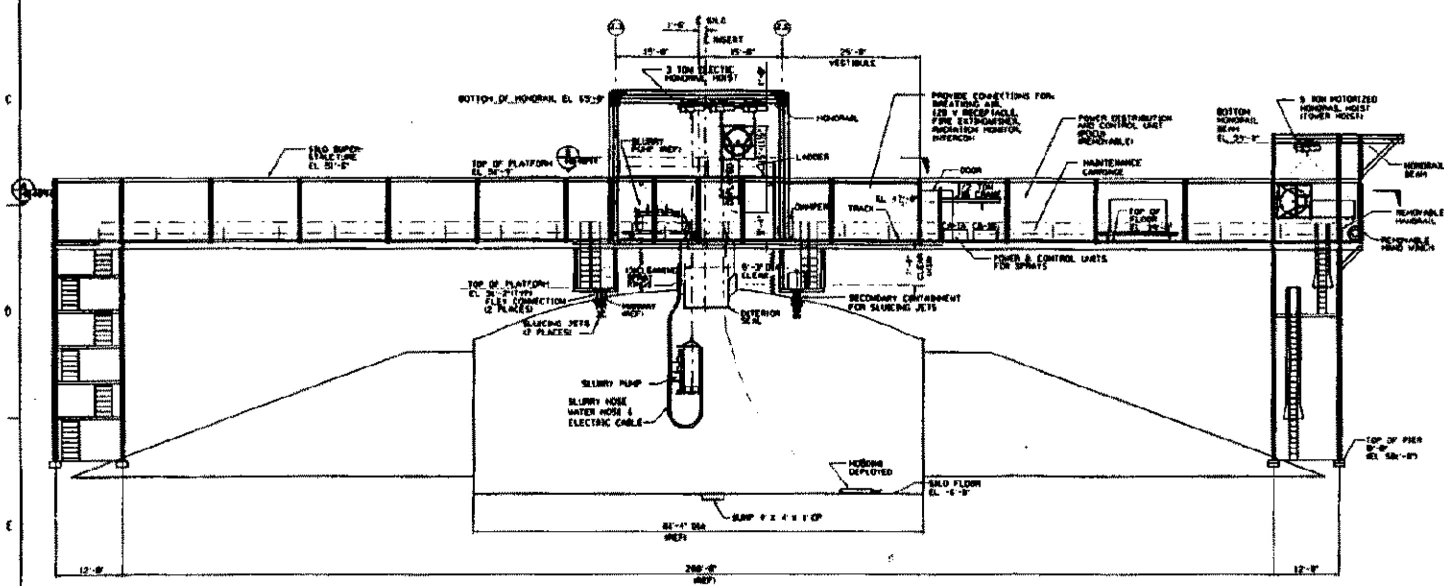
CINCINNATI, OHIO

SILO SUPERSTRUCTURE DESIGN FOR FRUP
RESIDUE RETRIEVAL CONCEPTUAL DESIGN

MATERIALS HANDLING
GENERAL ARRANGEMENT - PLAN
HYDRAULIC RETRIEVAL SILO 1 & 2

N/A

OU4/P0161 | 40200 | WBS 1.1.1.4.3.2 00-90701 | SK-M-84094 | M0001 | B




ELEVATION

NOTES

1. A CONTAINER, MOUNTED ON MAINTENANCE CARRIAGE, WILL BE UTILIZED FOR SLURRY PUMP REMOVAL AND CONTAINMENT. TWO DRAINAGE PLUGS ARE PROVIDED, ONE ON EACH END OF THE BOX.
2. THE ENVELOPE FOR PUMP CLEARANCE IS 5' x 5' x 10' WITH A PUMP WEIGHT OF APPROXIMATELY 4000 POUNDS.
3. A MOBILE CRANE WILL BE USED FOR INSTALLATION, REMOVAL, MAINTENANCE OF THE SLUICING JET EQUIPMENT.

| REF DWG NO. | DRAWING TITLE |
|---|---|
| SK-Y-04153 | DRAWING INDEX |
| SK-H-84094 | HYDRAULIC RETRIEVAL SILO 1 & 2 - PLAN |
| SK-S-04162 | ELEVATION - SILO 1 & 2 SUPERSTRUCTURE |

PRELIMINARY
NOT FOR CONSTRUCTION

| REV | DESCRIPTION |
|---|---|
| B | ISSUED FOR CONCEPTUAL DESIGN |
| A | 90% CONCEPTUAL DESIGN PACKAGE |

UNITED STATES DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

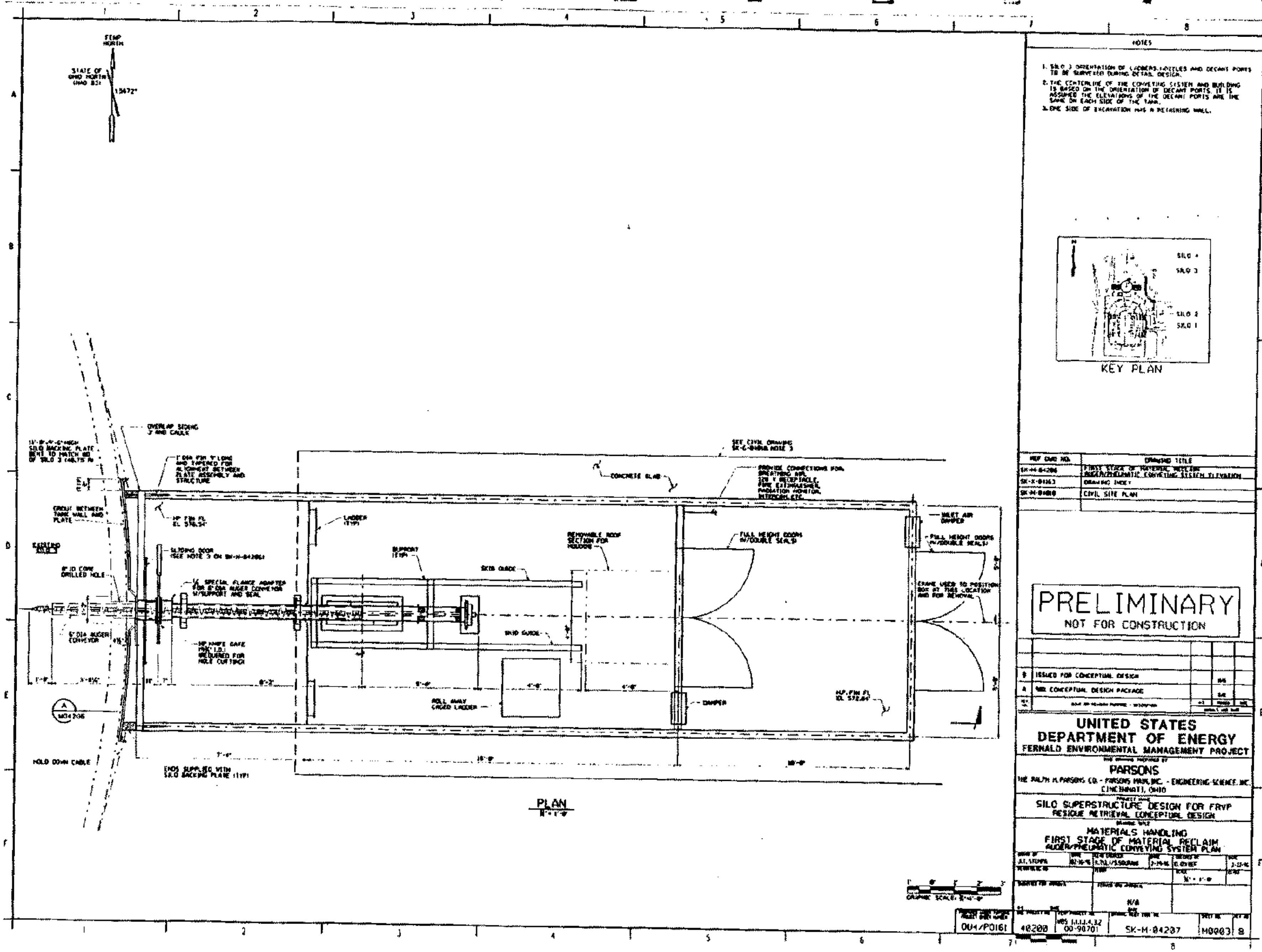
PARSONS
THE RALPH M. PARSONS CO. - PARSONS MAIN INC. - ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

SILO SUPERSTRUCTURE DESIGN FOR FRUP RESIDUE RETRIEVAL CONCEPTUAL DESIGN

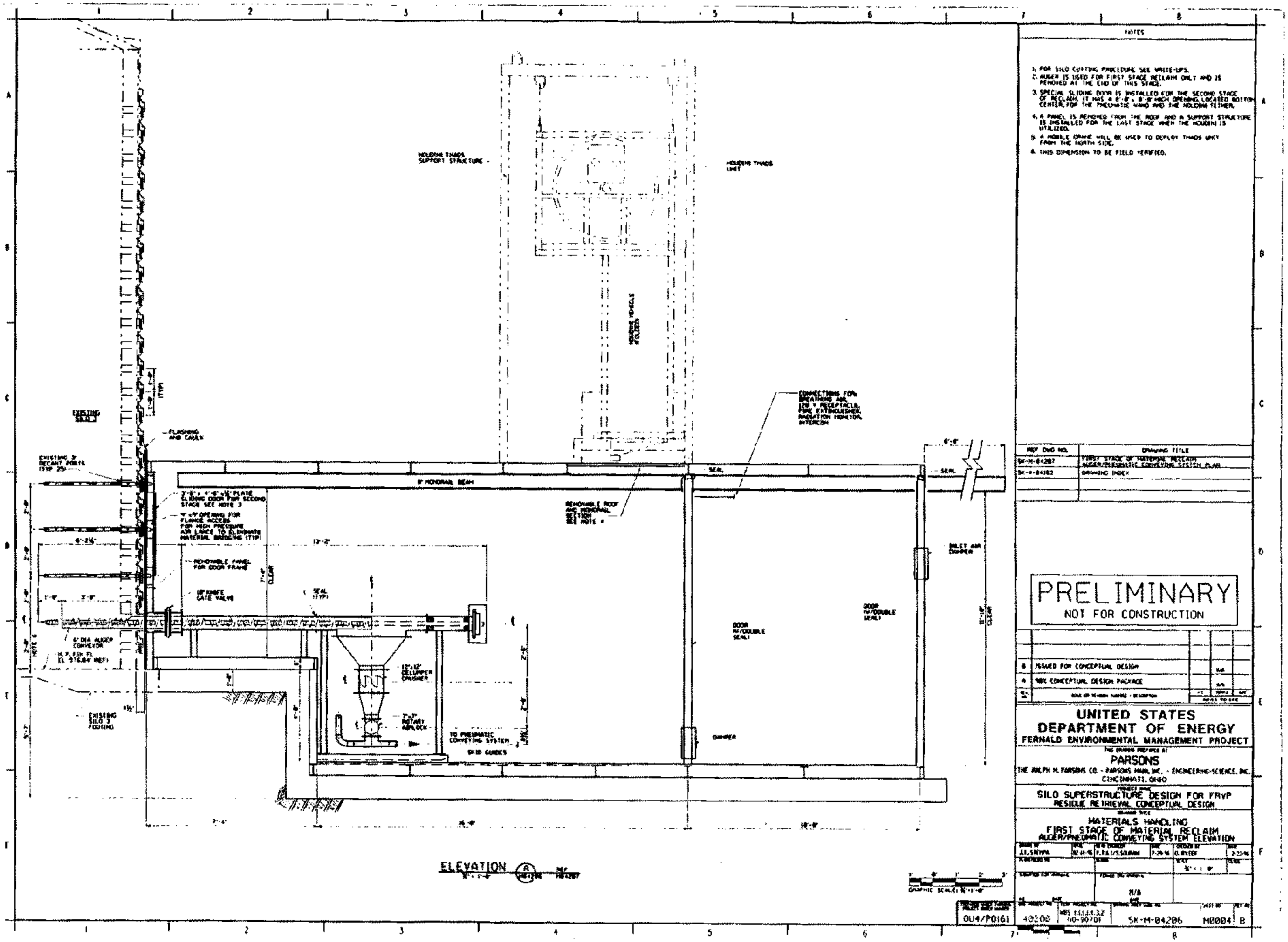
MATERIALS HANDLING
GENERAL ARRANGEMENT - ELEVATION
HYDRAULIC RETRIEVAL SILO 1 & 2

N/A

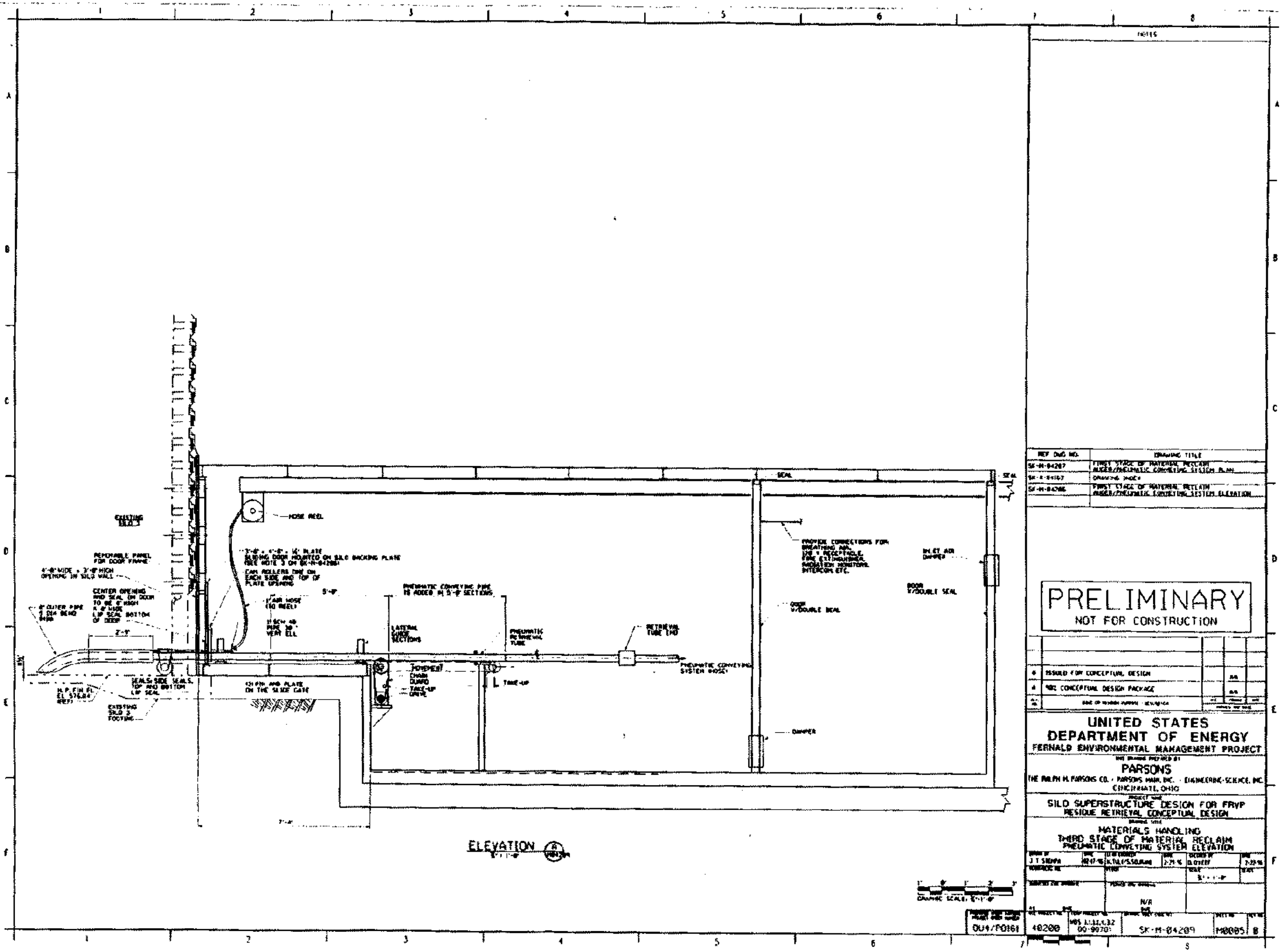
OU4/PO161 | 40200 | WBS 1.1.1.4.3.7 00-90701 | SK-H-84095 | M0002 | B




skm04207.m po161@ws320. Fri Mar 29 14:09:32 CST 1996




skm04206.m po161@ws316. Mon Apr 1 13:39:28 CST 1996

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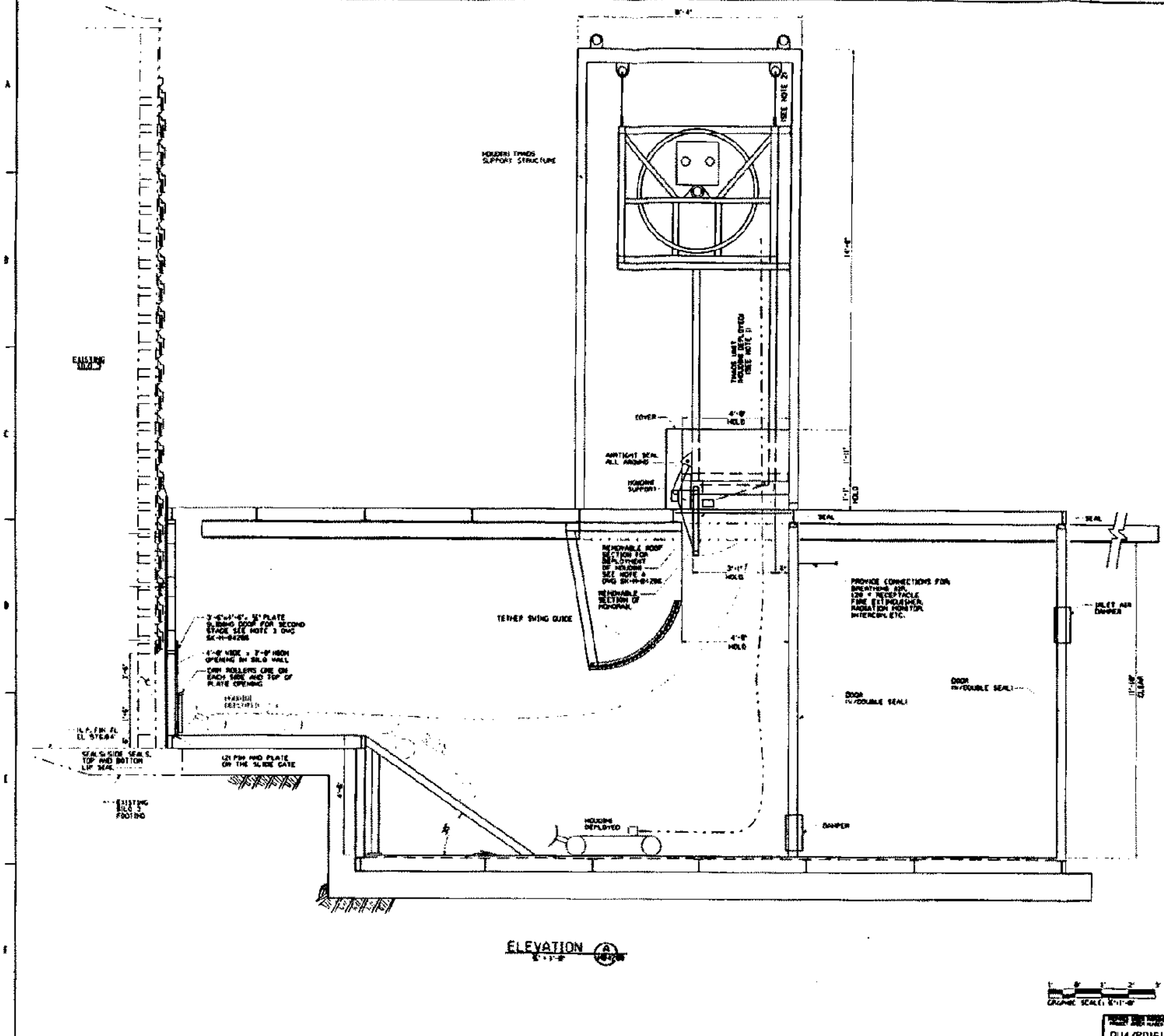


NOTES

1. HOUDINI THADS UNIT IS ENCLOSED AND HEATED. THE UNIT BECOMES PART OF SECONDARY CONTAINMENT WHEN SEALED TO EC ROOF.
2. THADS SUPPORT STRUCTURE/THADS UNIT/EC INTERFACE DETAILS TO BE DEVELOPED DURING TITLE DESIGN.

| REF DWG NO. | DRAWING TITLE |
|---|---|
| SK-M-04207 | FIRST STAGE OF MATERIAL RECLAIM AUGER/PNEUMATIC CONVEYING SYSTEM PLAN |
| SK-X-04163 | DRAWING INDEX |
| SK-M-04206 | FIRST STAGE OF MATERIAL RECLAIM AUGER/PNEUMATIC CONVEYING SYSTEM ELEVATION |

PRELIMINARY
NOT FOR CONSTRUCTION

| | | | |
|---|---|---|---|
| B | ISSUED FOR CONCEPTUAL DESIGN | | |
| A | 90% CONCEPTUAL DESIGN PACKAGE | | |

UNITED STATES
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FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

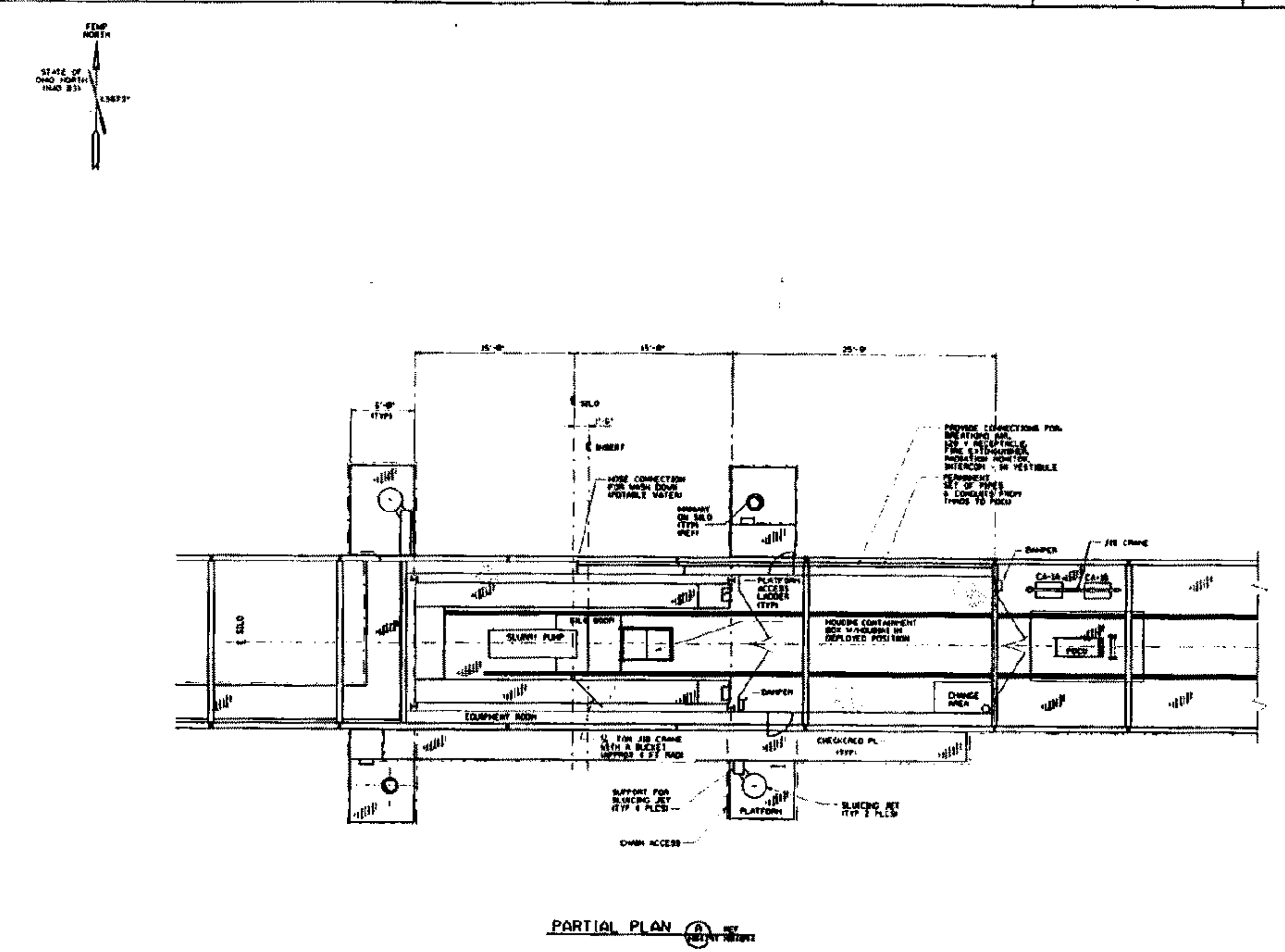
PARSONS
THE RALPH M. PARSONS CO. - PARSONS MAIN INC. - ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

SILO SUPERSTRUCTURE DESIGN FOR FRVP
RESIDUE RETRIEVAL CONCEPTUAL DESIGN

MATERIALS HANDLING
FOURTH STAGE OF MATERIAL RECLAIM
HOUDINI DEPLOYMENT ELEVATION

N/A

| | | | | | |
|---|---|---|---|---|---|
| QU4/P0161 | 40200 | WBS 1.1.1.4.3.7 00-90701 | SK-M-04208 | M0006 | B |




PARTIAL PLAN (A)

| REF DWG NO. | DRAWING TITLE |
|---|---|
| SK-H-04163 | DRAWING INDEX |
| SK-H-04094 | HYDRAULIC RETREIVAL SILOS 1 & 2 - PLAN |

**PRELIMINARY**
NOT FOR CONSTRUCTION

A ISSUED FOR CONCEPTUAL DESIGN

**UNITED STATES DEPARTMENT OF ENERGY**
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

PARSONS
THE RALPH M PARSONS CO. - PARSONS MAIN, INC. - ENGINEERING SCIENCE, INC.
CINCINNATI, OHIO

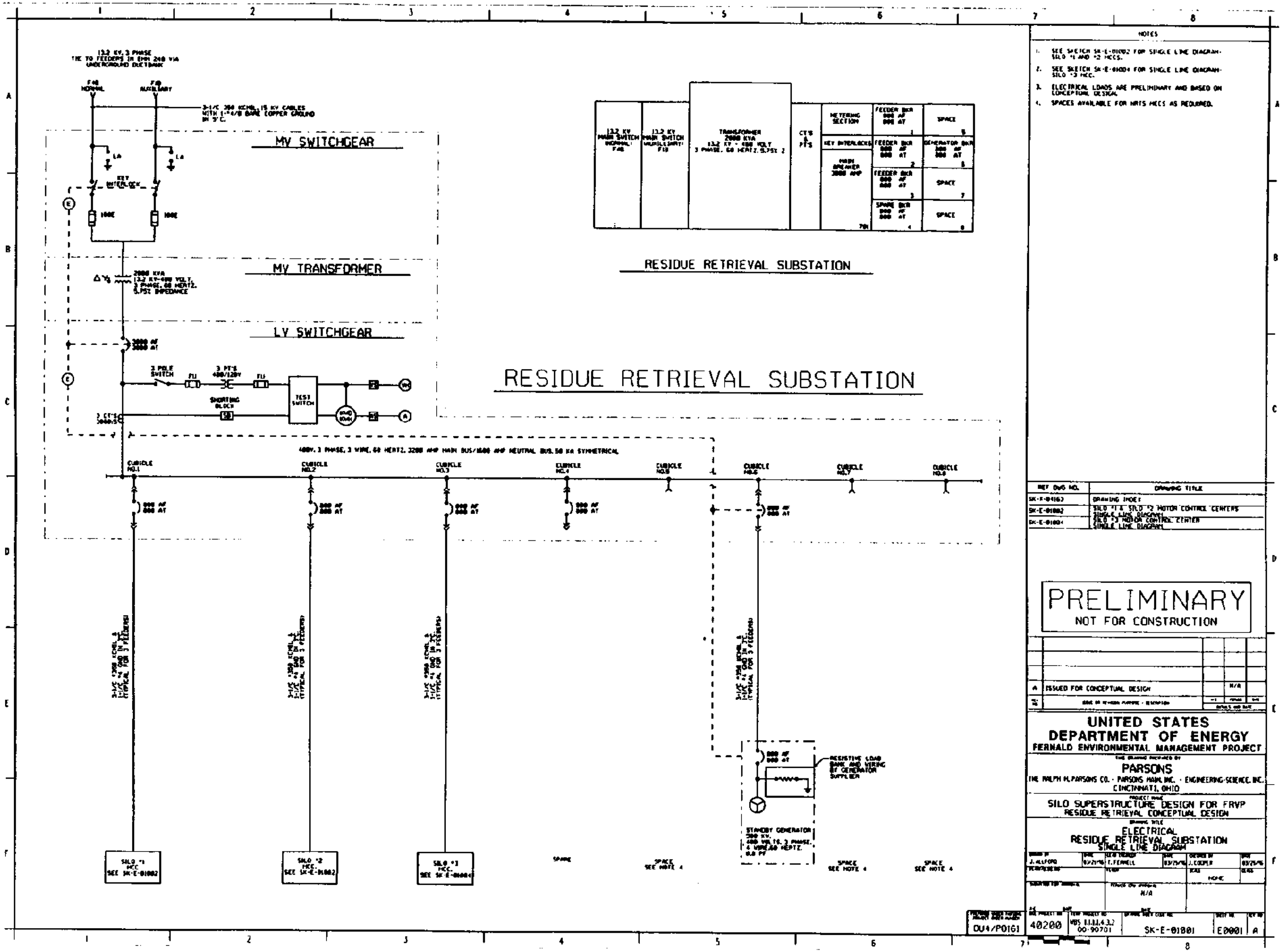
SILO SUPERSTRUCTURE DESIGN FOR FRUP
RESIDUE RETREIVAL CONCEPTUAL DESIGN

MATERIALS HANDLING
GENERAL ARRANGEMENT - PARTIAL PLAN
HYDRAULIC RETREIVAL SILOS 1 & 2

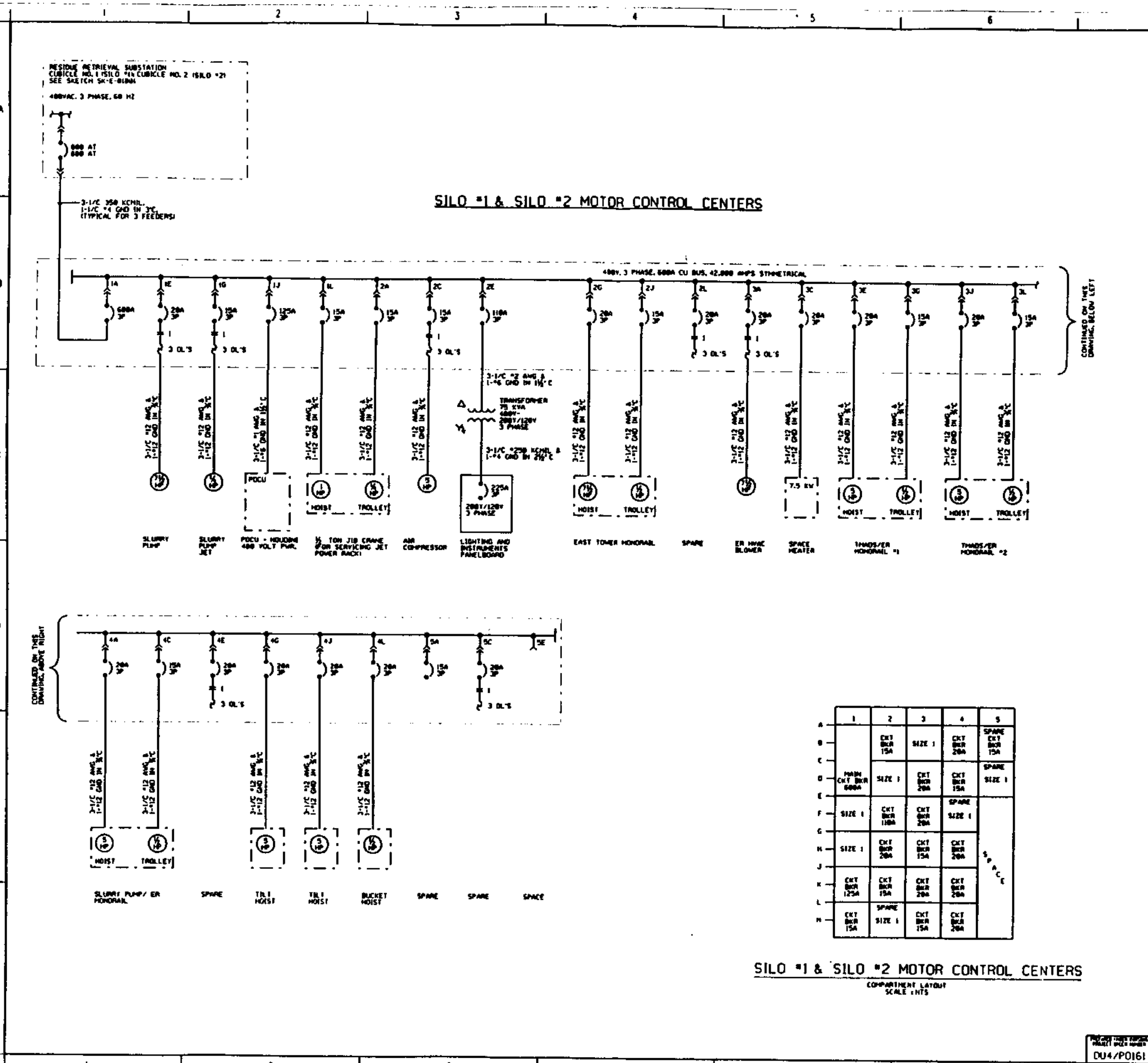
N/A

DU6/P0161 | 40200 | WBS 1.1.1.4.3.2 00-90701 | SK-H-04294 | H0007 | A

skm04294.m po161@ws320. Fri Mar 29 14:21:23 CST 1996




R94e01001.m po161@ws406. Mon Apr 1 14:44:18 CST 1996




NOTES

1. SEE SKETCH SK-E-01001 FOR RESIDUE RETRIEVAL SUBSTATION SINGLE LINE DIAGRAM.
2. ELECTRICAL LOADS ARE PRELIMINARY AND BASED ON CONCEPTUAL DESIGN.
3. TYPICAL FOR TWO (2) MCC'S, ONE FOR SILO #1 AND ONE FOR SILO #2.

| REF DWG NO. | DRAWING TITLE |
|---|---|
| SK-X-04163 | DRAWING INDEX |
| SK-E-01001 | RESIDUE RETRIEVAL SUBSTATION SINGLE LINE DIAGRAM |

PRELIMINARY
NOT FOR CONSTRUCTION

A ISSUED FOR CONCEPTUAL DESIGN N/A

UNITED STATES DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

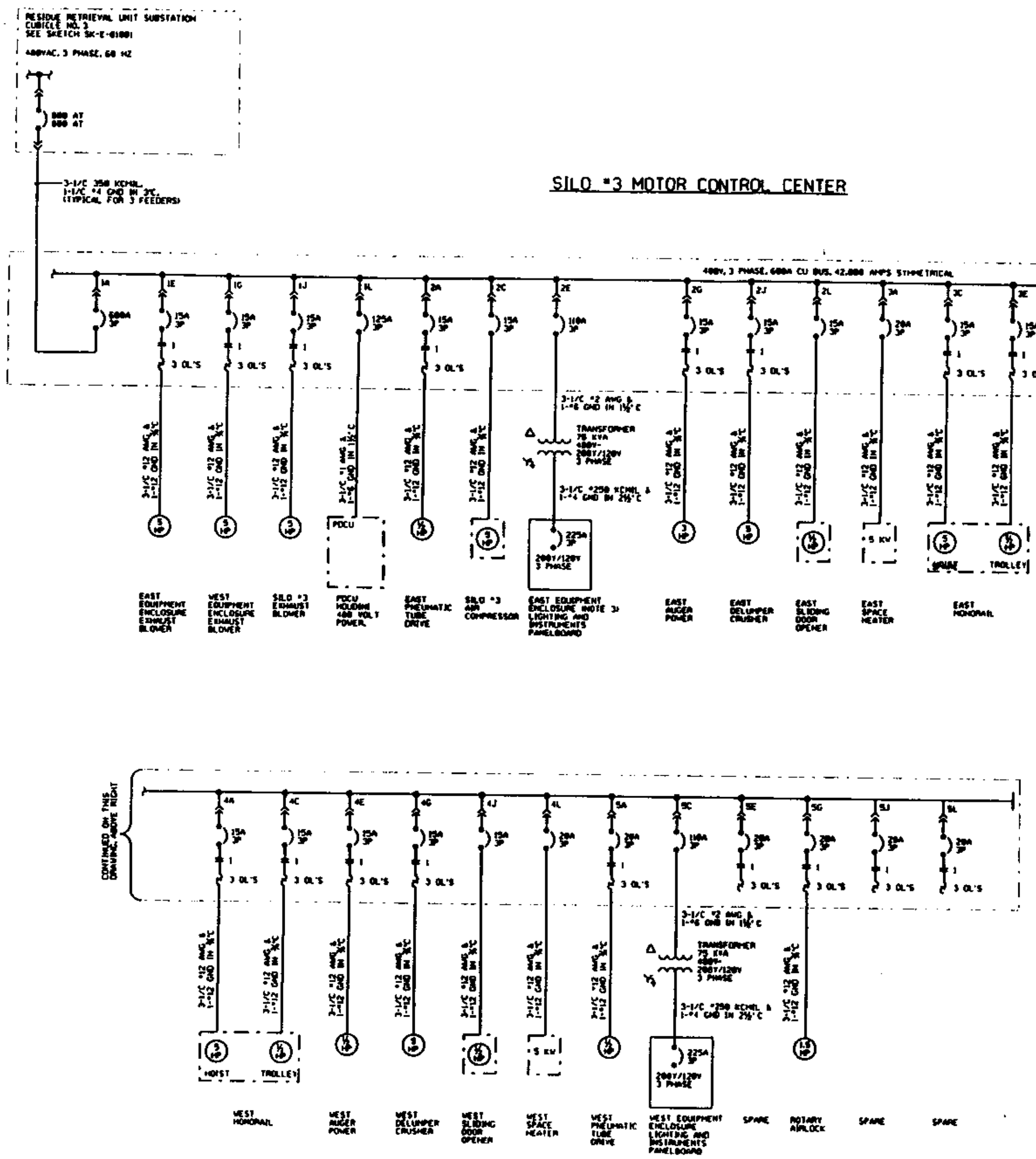
PARSONS
THE RALPH M. PARSONS CO. - PARSONS MAIN INC. - ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

SILO SUPERSTRUCTURE DESIGN FOR FRVP
RESIDUE RETRIEVAL CONCEPTUAL DESIGN

ELECTRICAL
SILO #1 & SILO #2 MOTOR CONTROL CENTERS
SINGLE LINE DIAGRAM

J. ALLFORD · T. FERRELL · J. COOPER · NONE · N/A

DU4/PO161 · 40200 · WBS 1.1.1.1.4.3.2 00-90701 · SK-E-01002 · E0002 · A




| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| A–C | MAIN CKT BKR 600A | SIZE 1 | CKT BKR 20A | SIZE 1 | SIZE 1 |
| C–E | | CKT BKR 15A | SIZE 1 | SIZE 1 | CKT BKR 110A |
| E–G | SIZE 1 | CKT BKR 110A | SIZE 1 | SIZE 1 | SPARE SIZE 1 |
| G–J | SIZE 1 | SIZE 1 | SIZE 1 | SIZE 1 | SIZE 1 |
| J–L | SIZE 1 | SIZE 1 | SIZE 1 | CKT BKR 15A | SPARE SIZE 1 |
| L–M | CKT BKR 125A | CKT BKR 15A | SIZE 1 | CKT BKR 20A | SPARE SIZE 1 |

SILO #3 MOTOR CONTROL CENTER

COMPARTMENT LAYOUT
SCALE: NTS

NOTES

1. SEE SKETCH SK-E-01001 FOR RESIDUE RETRIEVAL SUBSTATION SINGLE LINE DIAGRAM
2. ELECTRICAL LOADS ARE PRELIMINARY AND BASED ON CONCEPTUAL DESIGN.
3. SILO 3 HAS TWO EQUIPMENT ENCLOSURES POWERED BY THIS MCC. THEY ARE REFERRED TO AS THE EAST AND WEST EQUIPMENT ENCLOSURES.

| REF DWG NO. | DRAWING TITLE |
|---|---|
| SK-E-04163 | DRAWING INDEX |
| SK-E-01001 | RESIDUE RETRIEVAL SUBSTATION SINGLE LINE DIAGRAM |

PRELIMINARY
NOT FOR CONSTRUCTION

A ISSUED FOR CONCEPTUAL DESIGN N/A

UNITED STATES
DEPARTMENT OF ENERGY
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

PARSONS
THE RALPH M. PARSONS CO. - PARSONS MAIN, INC. - ENGINEERING-SCIENCE, INC.
CINCINNATI, OHIO

SILO SUPERSTRUCTURE DESIGN FOR FRVP
RESIDUE RETRIEVAL CONCEPTUAL DESIGN

ELECTRICAL
SILO #3 MOTOR CONTROL CENTER
SINGLE LINE DIAGRAM

J. ALLFORD 03/26/96 | T. FENNELL 03/26/96 | J. COOPER 03/25/96
SCALE: NONE
N/A

0U4/P0161 | 40200 | WBS 1.1.1.1.4.3.2 00-90701 | SK-E-01004 | E0003 | A

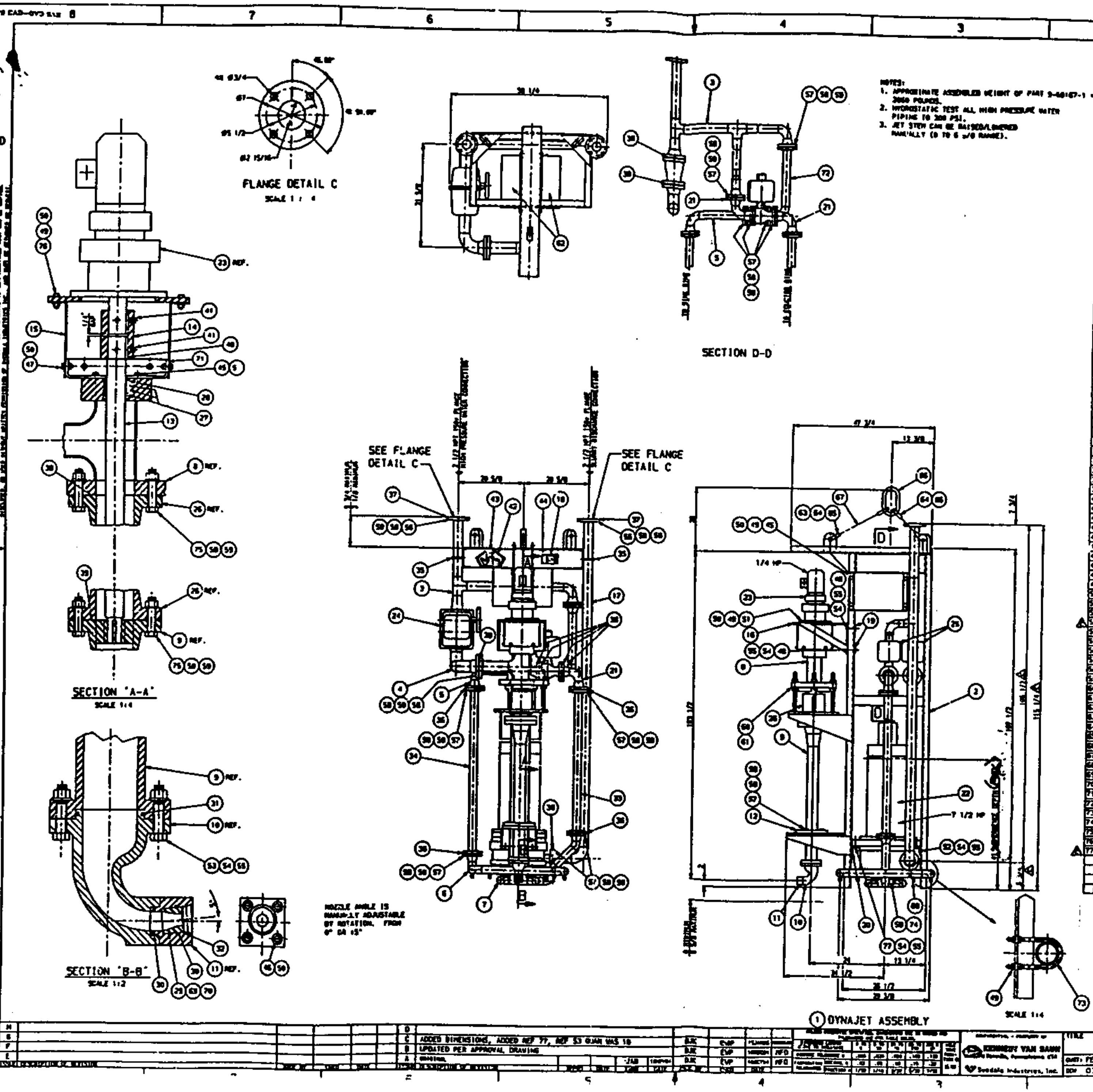
R94e01004.m po161@ws406. Mon Apr 1 15:17:18 CST 1996

# APPENDIX B

## MANUFACTURER'S DRAWINGS, CATALOG CUTS, AND SKETCHES

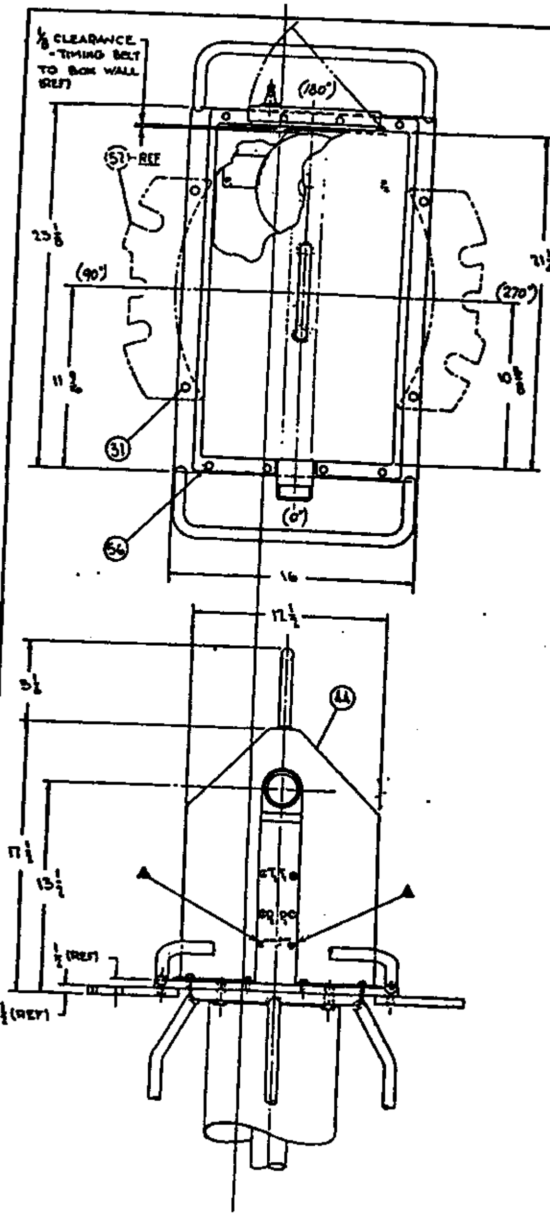
NOTES:
1. APPROXIMATE ASSEMBLED WEIGHT OF PART 9-69167-1 = 3060 POUNDS.
2. HYDROSTATIC TEST ALL HIGH PRESSURE WATER PIPING TO 300 PSI.
3. JET STEM CAN BE RAISED/LOWERED MANUALLY (0 TO 6 3/8 RANGE).

| Item | Qty | Description | Mfg. | Part No. / Spec No. |
|---|---|---|---|---|
| 1 | 1 | GENERAL ASSEMBLY MODEL DJ02851 DYNAJET | | 9-69167-1 |
| 2 | 1 | FRAME WELDMENT | | 9-69253-1 |
| 3 | 1 | HIGH PRESSURE WATER INLET PIPE | | 7-69254-1 |
| 4 | 1 | HIGH PRESSURE WATER MANIFOLD | | 5-69255-1 |
| 5 | 1 | SINK RING SECONDARY ELBOW WELDMENT | | 3-69372-1 |
| 6 | 1 | SINK RING WELDMENT | | 7-69257-1 |
| 7 | 1 | REDUCTOR RING WELDMENT | | 5-69258-1 |
| 8 | 1 | DRIVE HOUSING WELDMENT | | 7-69326-1 |
| 9 | 1 | JET STEM WELDMENT | | 7-69305-1 |
| 10 | 1 | NOZZLE MACHINING | | 5-48574-1 |
| 11 | 1 | ORIFICE HOLDER | | 5-63820-1 |
| 12 | 1 | BEARING DETAIL | | 5-48552-1 |
| 13 | 1 | DRIVE SHAFT ASSEMBLY | | 7-69304-1 |
| 14 | 1 | SHAFT COUPLING | | 3-69307-1 |
| 15 | 1 | SHAFT EXTENSION COVER | | 3-69316-1 |
| 16 | 1 | DRIVE MOUNTING WELDMENT | | 7-69311-1 |
| 17 | 1 | ABRASION RESISTANT PIPE WELDMENT | | 5-69308-1 |
| 18 | 1 | INFORMATION NAMEPLATE | | 3-69375-1 |
| 19 | 2 | CLAMP BAR | | 7-69311-2 |
| 20 | 2 | MOTOR SUPPORT CLIP | | 9-69253-2 |
| 21 | 2 | ELBOW WELDMENT | | 3-69303-1 |
| 22 | 1 | 3" PUMP WITH 7 1/2 HP MOTOR 3PH/60HZ/460V | | |
| 23 | 1 | DOUBLE WORM GEAR SPEED REDUCER 3PH/60HZ/460V | | |
| 24 | 1 | FLANGED BALL VALVE 3"-150 LB | | |
| | | WITH ELECTRIC ACTUATOR 1/60HZ/115V | | |
| 25 | 2 | FLANGED BALL VALVE 2-150 LB | | |
| | | WITH ELECTRIC ACTUATOR 1/60HZ/115V | | |
| 26 | 1 | SWIVEL 4-150 LB FLANGED END CONNECTIONS | | |
| 27 | 3 | PACKING RING 2 3/4 OD X 2 ID X 1/2 THK | [illegible] | |
| 28 | 1 | BACK-UP RING 2 3/4 OD X 2 ID X 3/8 THK | [illegible] | |
| 29 | 1 | ORIFICE 1/2 REGULAR | [illegible] | |
| 30 | 2 | O-RING 1 5/16 ID X 1 9/16 OD X | [illegible] | |
| | | 1/8" CROSS SECTION | | |
| 31 | 1 | O-RING 3 3/8 ID X 3 3/4 OD X | [illegible] | |
| | | 3/16 CROSS SECTION | | |
| 32 | 1 | SNAP RING | S.SPL | |
| 33 | 1 | 2 ID WATER HOSE ASSY. X 6'-0 LG. OVERALL | | |
| | | 300 PSI WORKING PRESSURE W/2-150 LB FLGS | | |
| 34 | 1 | 2 ID WATER HOSE ASSY. X 5'-0 LG. OVERALL | | |
| | | 300 PSI WORKING PRESSURE W/2-150 LB FLGS | | |
| 35 | 2 | U-BOLT 1/2 X 2 1/2 W/(4) HEX NUTS EA. | SPL | |
| 36 | 9 | 2-150 LB RING GASKET X 1/8 THICK | [illegible] | |
| 37 | 2 | 2 1/2-150 LB RING GASKET X 1/8 THICK | [illegible] | |
| 38 | 3 | 3-150 LB RING GASKET X 1/8 THICK | [illegible] | |
| 39 | 2 | 4-150 LB RING GASKET X 1/8 THICK | [illegible] | |
| 40 | 1 | KEY 1/2 X 1/2 X 2 3/8 LG. ROUND END | [illegible] | |
| 41 | 4 | [illegible] 3/4 LG-HEX SOC. FL. PT. | [illegible] | |
| 42 | 1 | KVS INSIGNIA | | 5-50495-1 |
| 43 | 5 | DRIVE SCREW NO 10 X 3/8 LG TYPE U | SPL | |
| 44 | 4 | DRIVE SCREW NO 4 X 1/4 LG TYPE U | SPL | |
| 45 | 12 | BOLT, HEX HD 3/8-16UNC-2A X 1 LG. | [illegible] | |
| 46 | 4 | BOLT, HEX SOC HD. 3/8-16UNC-2A X 2 1/2 LG. | [illegible] | |
| 47 | 8 | BOLT, HEX HD. 3/8-16UNC-2A X 3/4 LG. | [illegible] | |
| 48 | 4 | BOLT, HEX HD 1/2-13UNC-2A X 4 LG. | [illegible] | |
| 49 | 30 | NUT, HEX 3/8-16UNC-2B | [illegible] | |
| 50 | 30 | WASHER, LOCK 3/8 DIA. | [illegible] | |
| 51 | 8 | BOLT, HEX HD 3/8-16UNC-2A X 1 3/4 LG. | [illegible] | |
| 52 | 6 | BOLT, HEX HD 1/2-13UNC-2A X 1 3/4 LG. | [illegible] | |
| 53 | 6 | BOLT, HEX HD 1/2-13UNC-2A X 2 3/4 LG. | [illegible] | |
| 54 | 20 | NUT, HEX 1/2-13UNC-2B | [illegible] | |
| 55 | 20 | WASHER, LOCK 1/2 DIA. | [illegible] | |
| 56 | 20 | BOLT, HEX HD 5/8-11UNC-2A X 3 LG. | [illegible] | |
| 57 | 40 | BOLT, HEX HD 5/8-11UNC-2A X 2 3/4 LG. | [illegible] | |
| 58 | 84 | NUT, HEX 5/8-11UNC-2B | [illegible] | |
| 59 | 87 | WASHER, LOCK 5/8 DIA. | [illegible] | |
| 60 | 6 | NUT, HEX 1-8UNC-2B | [illegible] | |
| 61 | 6 | WASHER, PLAIN 1 TYPE B | [illegible] | |
| 62 | 2 | ELECTRICAL BOX (SEE UNIT #02) | | |
| 63 | 3 | ANCHOR SHACKLE WITH PIN SIZE 1 1/8 | | |
| 64 | 6 | WIRE ROPE THIMBLE-7/8 DIA. WIRE ROPE | | |
| 65 | 24 | U-BOLT WIRE ROPE CLIP-7/8 DIA. WIRE ROPE | | |
| 66 | 1 | WELDED OBLONG LINK 1 STOCK SIZE | | |
| 67 | 1 | HOISTING WIRE ROPE 7/8 DIA. (CUT TO SIZE) | | |
| 68 | 16 | SPRAY NOZZLE | | |
| 69 | 1 | SPARE ORIFICE 7/16 REGULAR | [illegible] | |
| 70 | 1 | SPARE ORIFICE 9/16 REGULAR | [illegible] | |
| 71 | 1 | PACKING RETAINER | | 3-69374-1 |
| 72 | 1 | SINK RING PRIMARY ELBOW WELDMENT | | 3-69376-1 |
| 73 | 2 | U-BOLT | | 3-69317-1 |
| 74 | 3 | BOLT, HEX HD. 5/8-11UNC-2A X 1 LG. | [illegible] | |
| 75 | 16 | BOLT, HEX HD. 5/8-11UNC-2A X 3 1/2 LG. | [illegible] | |
| 76 | 8 | BOLT, HEX HD. 3/8-16UNC-2A X 1 1/4 LG. | [illegible] | |
| 77 | 4 | BOLT, HEX HD. 1/2-13UNC-2A X 3 1/4 LG. | [illegible] | |

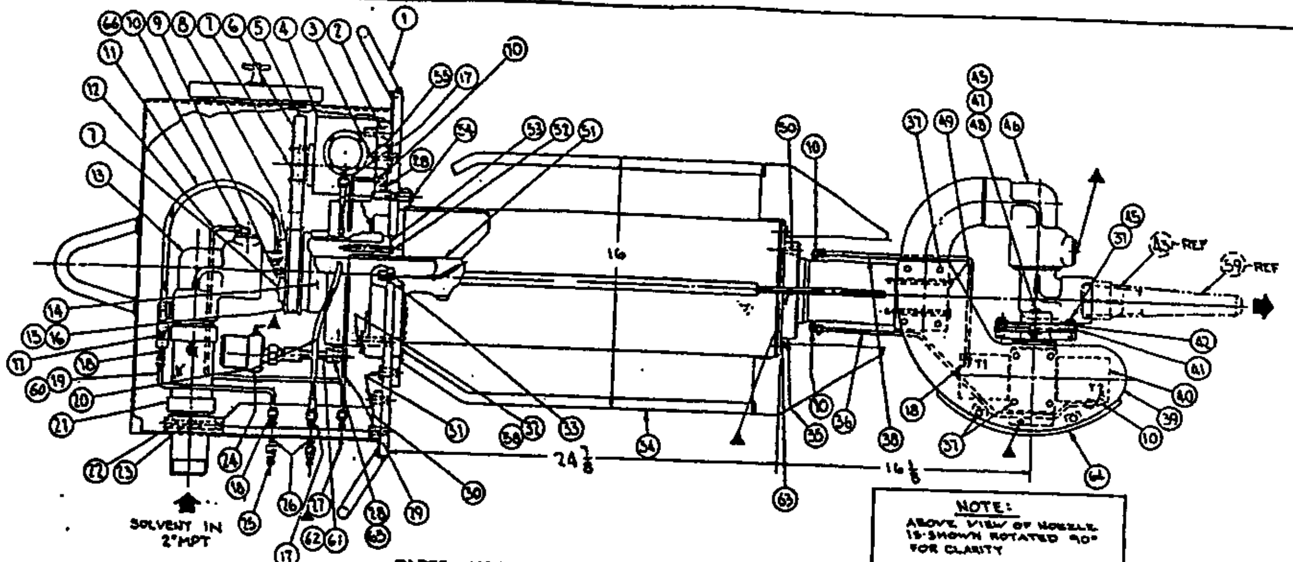



MARCONAFLO DYNA-JET
SLURRY PUMP

B-1









**NOTE:**
ABOVE VIEW OF NOZZLE IS SHOWN ROTATED 90° FOR CLARITY

**PARTS LIST**

| | | | | |
|---|---|---|---|---|
| 1 | 1 | PC | C-4215 | PLATE WELDT |
| 2 | 2 | PC | SHCS | 1/2-13NC x 1 1/4 |
| 3 | 2 | PC | HHCS | 1/2-13NC x 1 1/4 |
| 4 | 1 | PC | D-4210 | P80 ROTAC (GROUP) |
| 5 | 1 | PC | A-4274 | BELT (66T) |
| 6 | 1 | PC | B-4265 | PULLEY (DRIVER) (45T) |
| 7 | 2 | PC | HHCS | 5/16-18NC x 1" |
| 8 | 4 | PC | HHCS | 5/16-18NC x 1 1/4 |
| 9 | 2 | PC | A-904 | ELBOW-ADAPTER |
| 10 | 5 | PC | A-980 | MALE ELBOW |
| 11 | 2 | PC | A-4316 | HOSE |
| 12 | 1 | PC | C-4612 | TUBE (LUBE) |
| 13 | 1 | PC | C-4211 | SWIVEL (GROUP) |
| 14 | 1 | PC | C-4258 | BEARING |
| 15 | 2 | PC | B-4213 | FLANGE |
| 16 | 1 | PC | B-4262 | PULLEY (DRIVEN)(32T) |
| 17 | 2 | PC | A-939 | MALE ADAPTER |
| 18 | 12 | PC | A-2076 | FITTING |
| 19 | 2 | PC | C-4610 | TUBE (HYD) |
| 20 | 2 | PC | A-16861 | HOSE (HYD) |
| 21 | 1 | PC | B-4276 | COMPENSATOR |
| 22 | 1 | PC | B-4261 | CLAMP |
| 23 | 2 | PC | HHCS | 1/2-13NC x 2 |
| 24 | 1 | PC | A-4388 | LUBRICATOR |
| 25 | 4 | PC | A-3506 | PLUG |
| 26 | 4 | PC | A-2399 | NIPPLE |
| 27 | 2 | PC | A-3537 | GREASE FITTING |
| 28 | 2 | PC | A-4367 | ELBOW-STREET |
| 29 | 1 | PC | C-4616 | TUBE (LUBE) |
| 30 | 1 | PC | C-4266 | SUPPORT WELDT |
| 31 | 8 | PC | HHCS | 1/2-13NC x 1" |
| 32 | 4 | PC | HHCS | 1/2-13NC x 1 3/4 |
| 33 | 2 | PC | SHCS | 3/8-16NC x 3/8 |
| 34 | 1 | PC | D-4282 | TRUNK WELDT |
| 35 | 1 | PC | B-4321 | BEARING (GROUP) |
| 36 | 1 | PC | D-4614 | TUBE (HYD) |
| 37 | 12 | PC | HHCS | 3/8-16NC x 1" |
| 38 | 1 | PC | C-4615 | TUBE (HYD) |
| 39 | 1 | PC | C-4251 | HANGER |
| 40 | 1 | PC | C-4278 | T80 ROTAC (GROUP) |
| 41 | 1 | PC | B-4597 | DISC-FLEX |
| 42 | 4 | PC | A-2767 | BUSHING-DISC |
| REF 43 | 1 | PC | B-4706 | STRAIGHTENER |
| 44 | 1 | PC | C-4291 | BOX ASSY |
| 45 | 4 | PC | FW | 3/8 |
| 46 | 1 | PC | D-4216 | SWIVEL (GROUP) |
| 47 | 2 | PC | HEX NUT | 3/8-16NC |
| 48 | 2 | PC | HHCS | 3/8-16NC x 1 3/4 |
| 49 | 4 | PC | HHCS | 3/8-16NC x 3 1/4 |
| 50 | 4 | PC | SHCS | 3/8-16NC x 1 1/4 |
| 51 | 1 | PC | C-4391 | TUBE ASSY |
| 52 | 2 | PC | HHCS | 3/8-16NC x 3 |
| 53 | 2 | PC | A-4211 | CLAMP |
| 54 | 4 | PC | HHCS | 1/2-13NC x 1 1/4 |
| 55 | 1 | PC | B-4263 | BRACKET |
| 56 | 8 | PC | HHCS | 5/16-18NC 3/4 |
| REF 57 | 2 | PC | C-4938 | HATCH PLATE |
| 58 | 12 | PC | FW | 1/2 |
| REF 59 | 1 | PC | C-4920 | NOZZLE (.688 O) |
| 60 | 1 | PC | C-4611 | TUBE (HYD) |
| 61 | 1 | PC | NIPPLE | 1/8 NPT x 2 |
| 62 | 1 | PC | COUPLING | 1/8 NPT |
| 63 | 2 | PC | A-2850-2 | HEX PLUG (1/4 NPT) |
| 64 | 1 | PC | C-9937 | GUARD WELDT |
| 65 | 1 | PC | | RED. BSHG - 1/4 MPT/1/8 FPT |
| 66 | 1 | PC | | RED. BSHG - 1/8 MPT/1/8 FPT |

**NOTES**

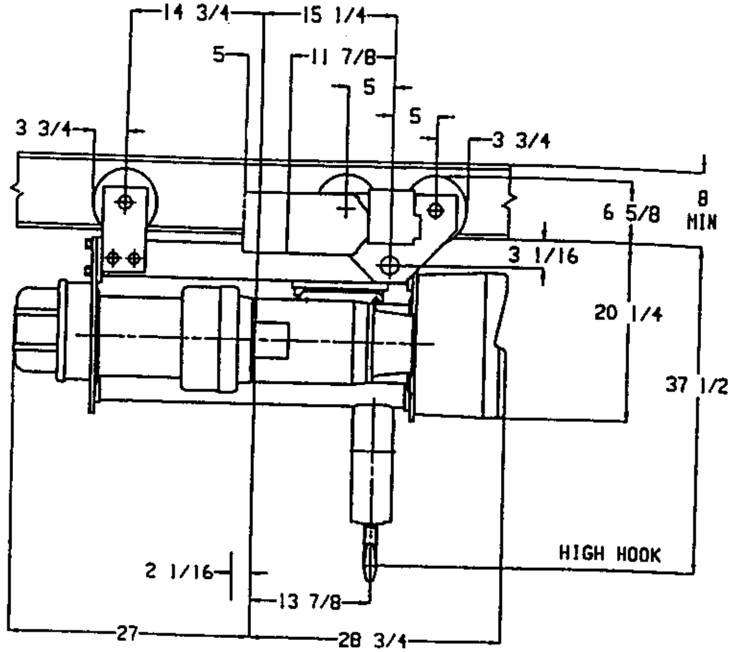
1- ALL HARDWARE TO BE 316 SS UNLESS OTHERWISE SPECIFIED
2- NOZZLE MOVEMENT:
PAN AXIS: 0° TO 360° AND BACK TO 0°
TILT AXIS: 153° UP FROM STRAIGHT DOWN
3- SEE INSTRUCTION MANUAL ON PROCEDURE FOR TIGHTENING TIMING BELT
4- SEE INSTRUCTION MANUAL FOR GREASING INSTRUCTIONS. ▲ = GREASE POINTS

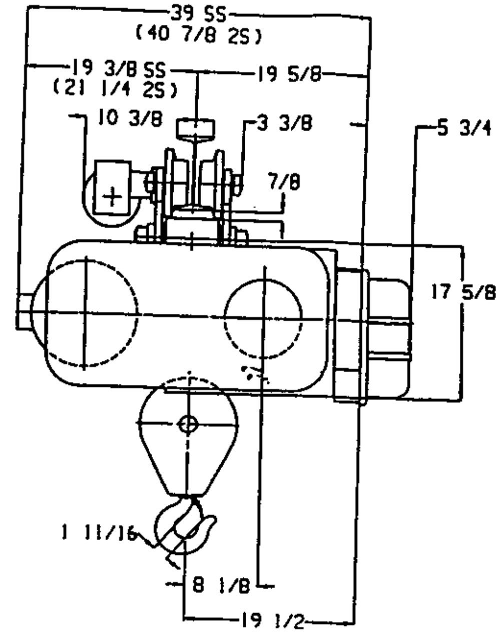
**BRISTOL EQUIPMENT COMPANY**

BRISTOL EQUIPMENT COMPANY
YORKVILLE, ILLINOIS
CCJ

| | | |
|---|---|---|
| SCALE 1/4 | 1-23-96 | JF |
| 11-26-80 | | 3-17-89 |
| TANK CLEANER | NOZZLE (GROUP) | U-8A |
| CAT # | R6 | D-4313 |

USED ON D-4458




4-CN-20

USTOMER: SORTECH SYSTEMS
.O. NO.: 6911
RODUCT NO.: 3380761 CAT.NO.:C3W05S066-22M2S0
APACITY: 5 TONS
IFT: 66 FT.
IFTING SPEED: 22/7 FPM @ 7.5/2.5 HP
ROLLEY TRAVEL SPEED: 33 FPM @ 1/2 HP

POWER SUPPLY: 480-3-60
P.B. STN. DROP: NONE
BEAM SIZE: S12 X 31.8#
REMARKS: SEE REGISTER
MARK: 4-CN-20
SERIAL NO(S).: 533-20-7155
REGISTER NO.: 1-14-7107. ITEM NO.:01

| CERTIFIED DRAWING | 11-30-94 | DDS |
|---|---|---|

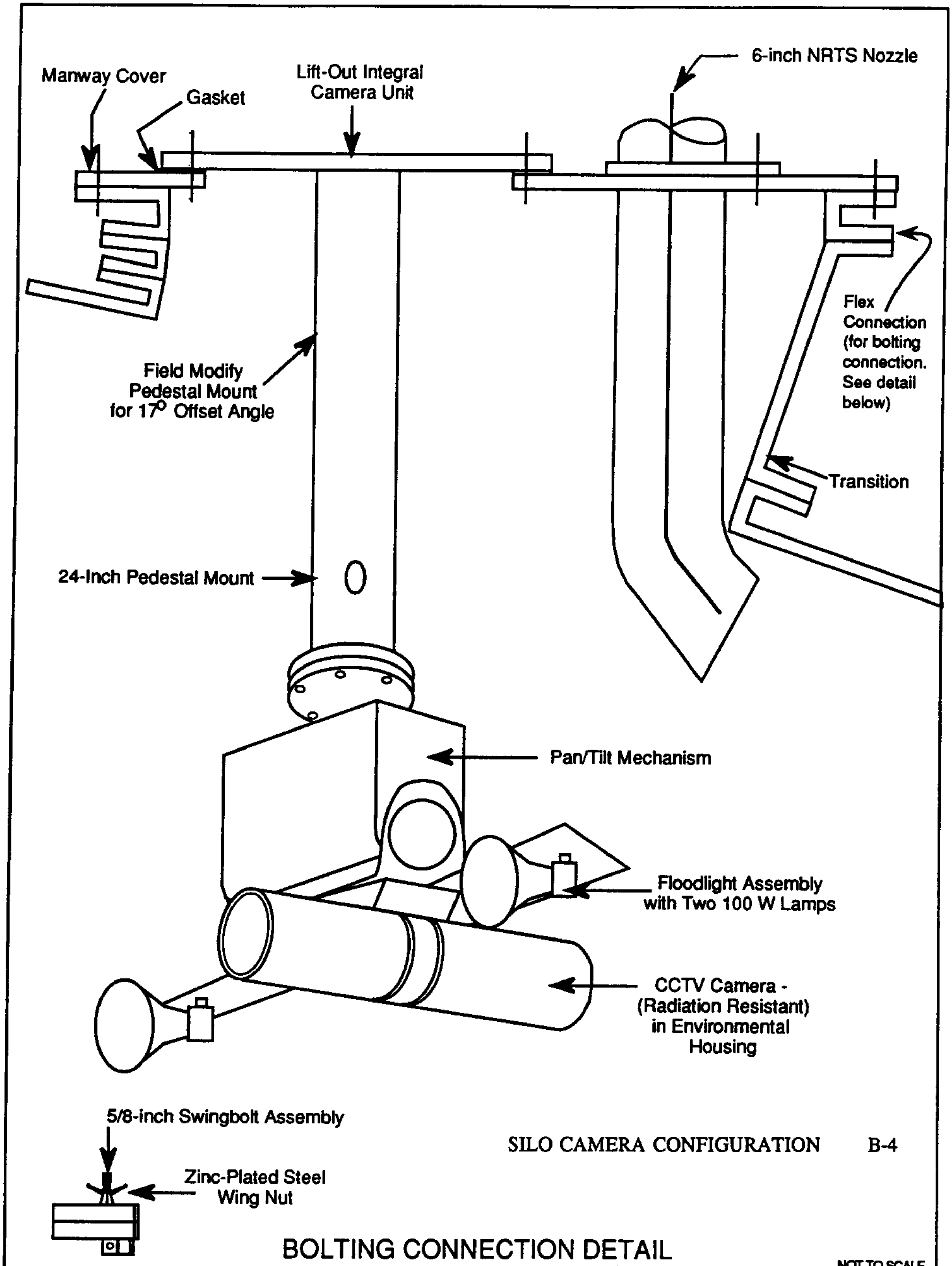
MOTORIZED TROLLEY B-3

ACCO Chain & Lifting Products Division, 76 Acco Dr., York PA. 17402

NAME: SERIES 33 2 P.S.- MOTORIZED TROLLEY

MATERIAL: HEAT TREAT:

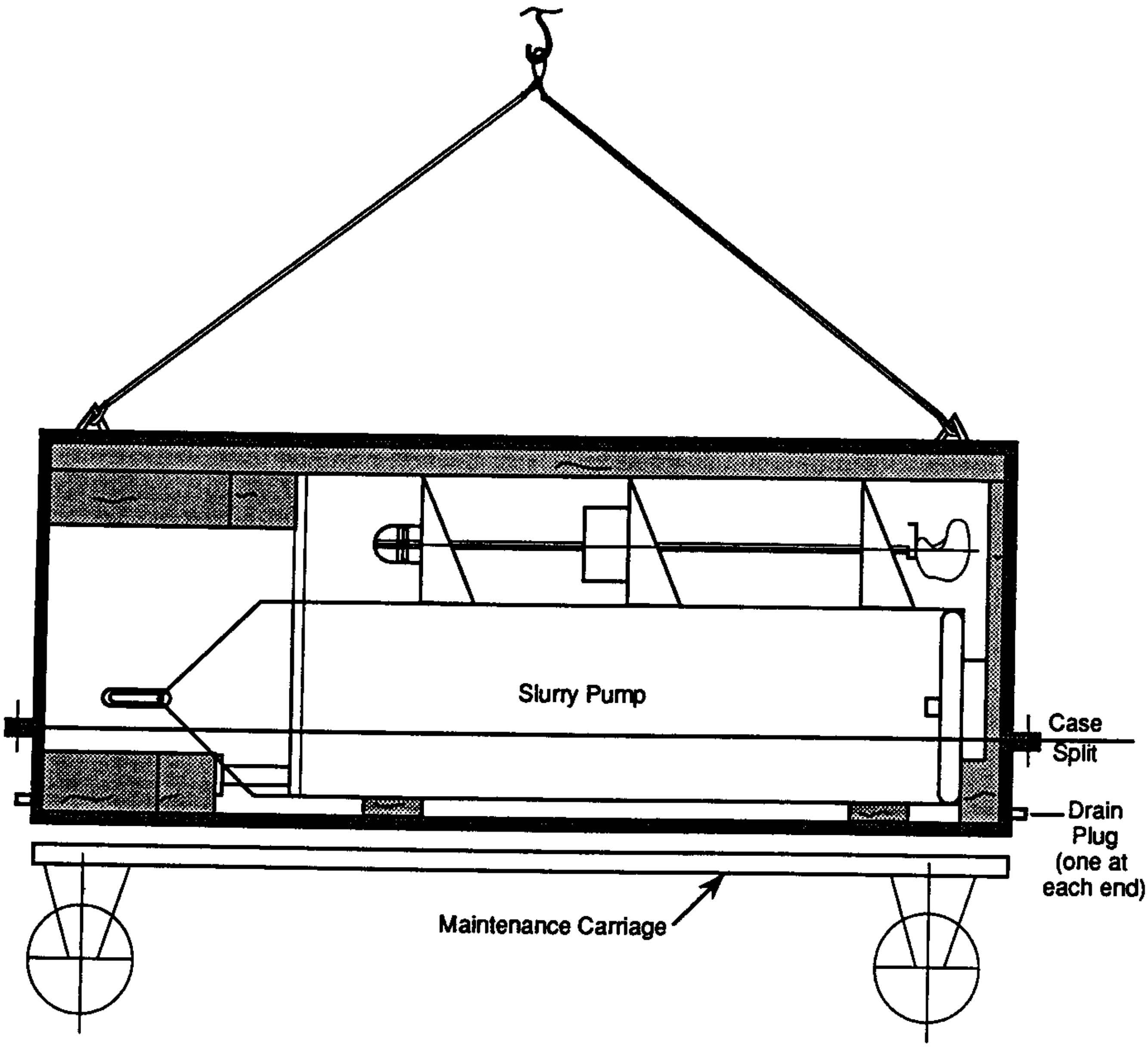
D 9147107-1




SILO CAMERA CONFIGURATION B-4

March 21, 1996

ILLUS/OU-4/PO-161/CCTV CAMERA.EPS




LEGEND

Soft Padding and Supports

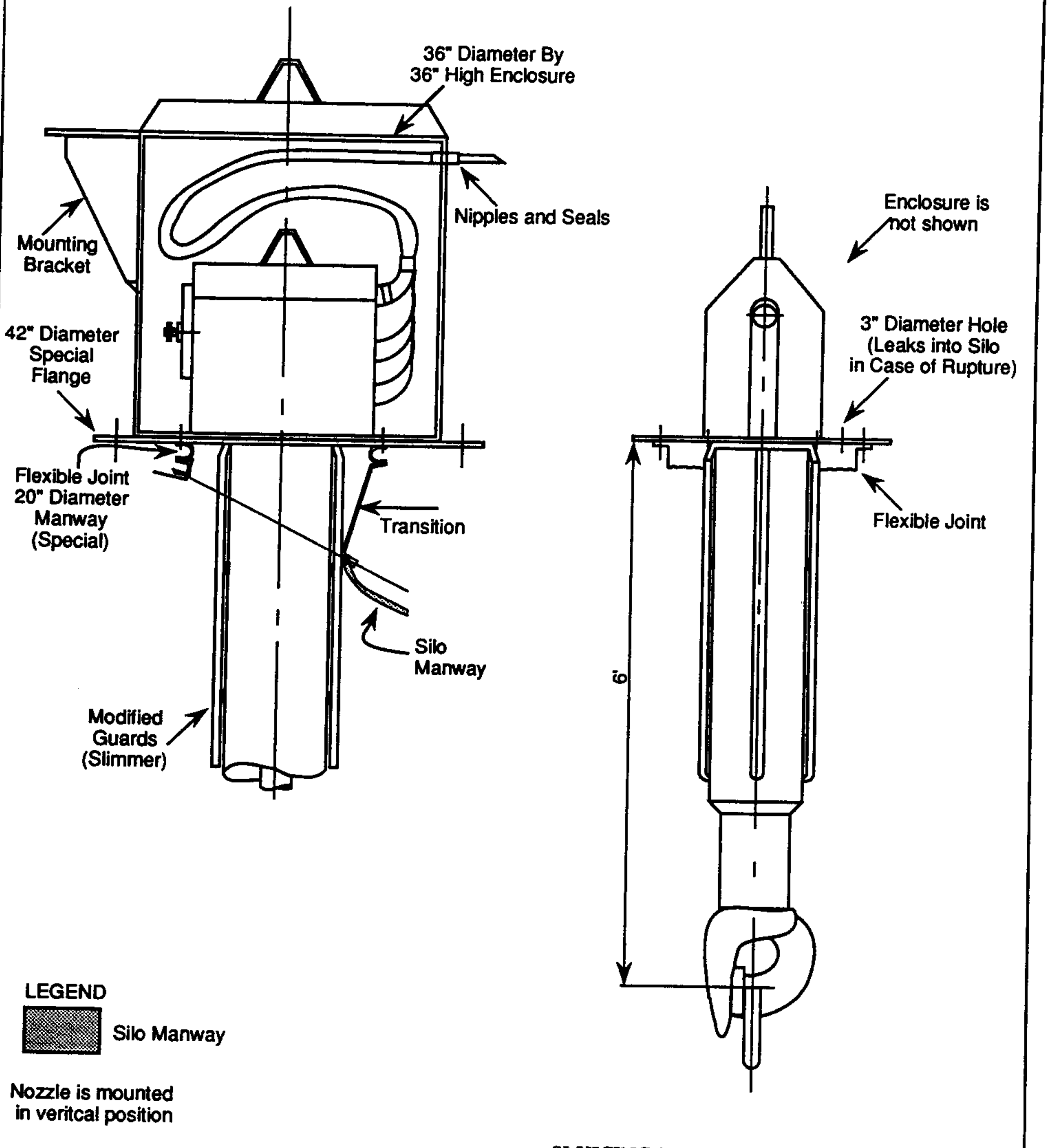
Container Casing

SLURRY PUMP TRANSPORT CONTAINER

B-5

SLURRY PUMP CONTAINER

NOT TO SCALE



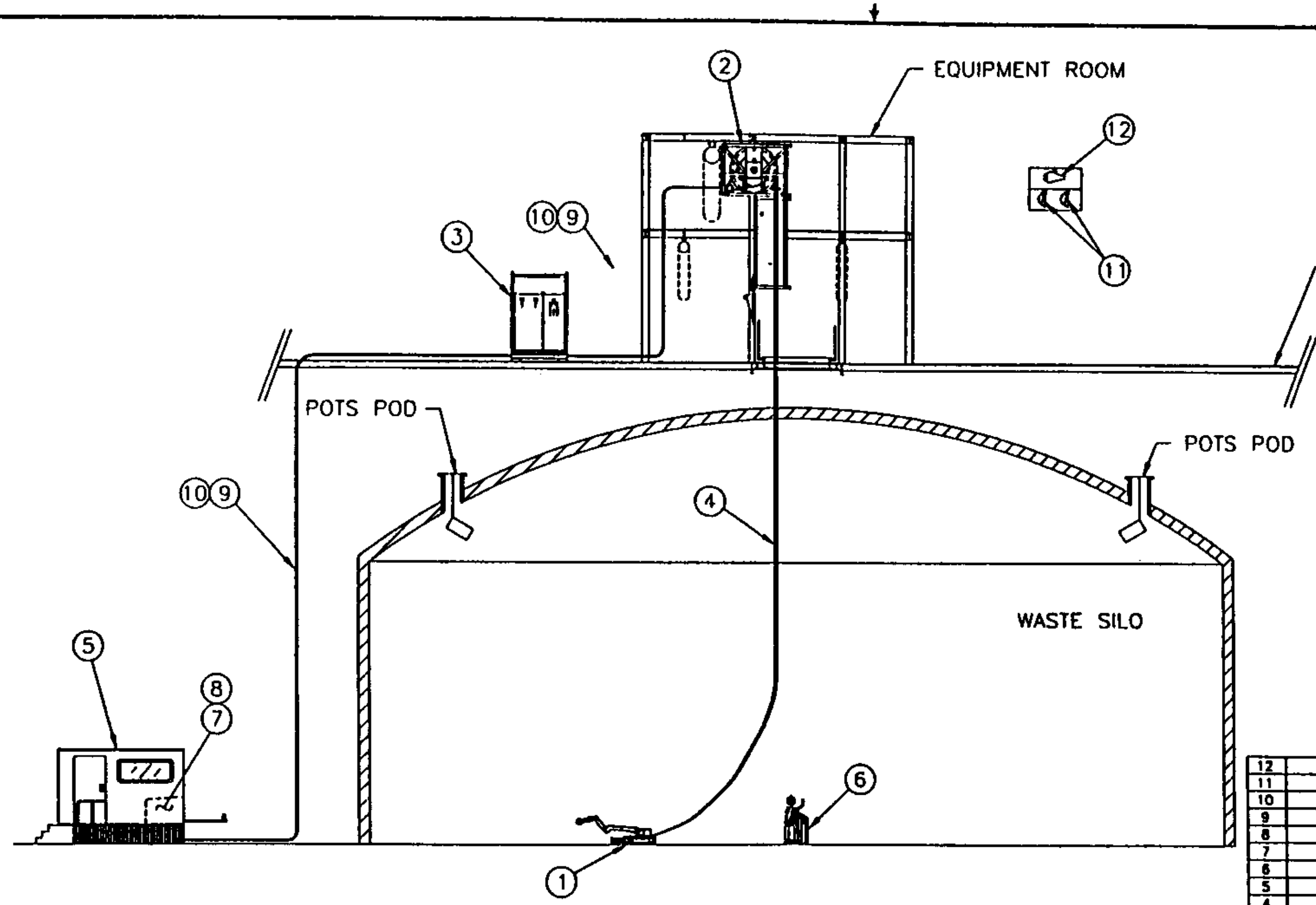

SLUICING JET ENCLOSURE

B-6

SLUICING JET INSTALLATION

NOT TO SCALE

March 21, 1996




| ITEM | PART NUMBER | DESCRIPTION |
|---|---|---|
| 12 | 9411-0115 | SHEAR ASSEMBLY |
| 11 | 9411-0211 | SCOOP ASSEMBLY |
| 10 | 9411-0003 | SYSTEM BLOCK DIAGRAM |
| 9 | 9411-0057 | SYSTEM INTERCONNECT BLOCK DIAGRAM |
| 8 | 9411-0011 | SUITCASE CONTROLLER |
| 7 | 9411-0009 | CONTROL CONSOLE |
| 6 | 9411-0184 | LOCAL SLUICER |
| 5 | 9411-0079 | COMMAND TRAILER |
| 4 | 9411-0008 | TETHER ASSEMBLY |
| 3 | 9411-0080 | POCU ASSEMBLY |
| 2 | 9411-0105 | TMADS ASSEMBLY |
| 1 | 9411-0121 | HOUDINI VEHICLE ASSEMBLY |

REVISIONS

| REV | DESCRIPTION | DATE | APPROVED |
|---|---|---|---|

| DASH NO | NEXT ASSY | QTY |
|---|---|---|

DRAWING REFERENCE

UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK ALL SHARP EDGES TO .015 MAX.
CHAMFER 1ST THREAD ON EXTERNAL THREADS 45°.
C'SK 1ST THREAD OF TAPPED HOLES 90° TO MAJOR DIA.
DIMENSIONING AND TOLERANCING IN ACCORDANCE WITH ASME Y14.5M-1994.

DO NOT SCALE DRAWING
ALL DIMENSIONS ARE IN INCHES
TOLERANCES: X.XX ±.020, X.XXX ±.005, ANGLES ±0°30'
SURFACE TEXTURE 125

THIRD ANGLE PROJECTION
TREATMENT:
MATERIAL:

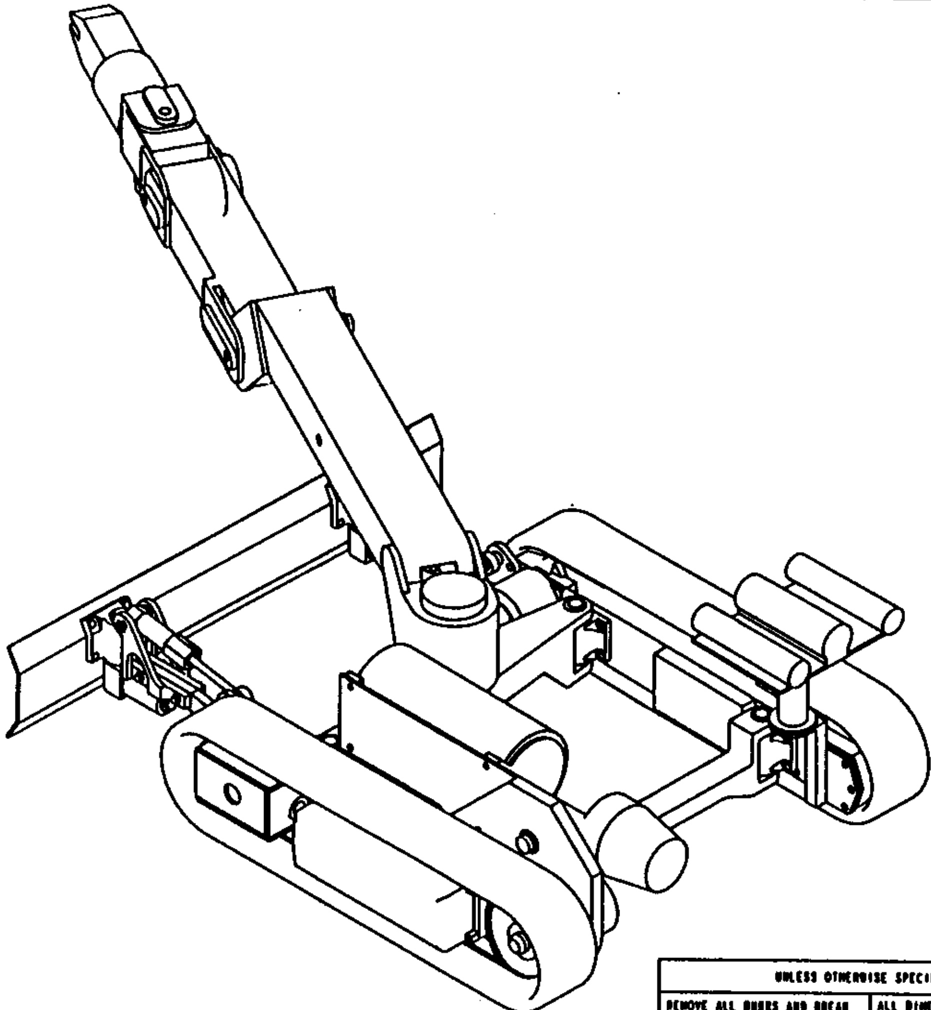
AUTHORIZATION

| | | |
|---|---|---|
| DFTG: | JVB | 2/9/96 |
| DSGNR: | | |
| CHKR: | | |
| ENGR: | | |
| APP: | | |
| APP: | | |

REDZONE ROBOTICS, INC.
2425 LIBERTY AVENUE
PITTSBURGH, PA 15222-4639
412-765-3064

HOUDINI SYSTEM OVERVIEW

CAGE CODE: 0K896 | SIZE: B | 9411-0000 | REV: –
SCALE: | WEIGHT: | SHEET 1 OF



| ITEM | PART NUMBER | DESCRIPTION | MATERIAL | MANUFACTURER | QTY |
|---|---|---|---|---|---|

UNLESS OTHERWISE SPECIFIED:

REMOVE ALL BURRS AND BREAK ALL SHARP EDGES TO .015 MAX. CHAMFER 1ST THREAD ON EXTERNAL THREADS 45° C'SK 1ST THREAD OF TAPPED HOLES 90° TO MAJOR DIA DIMENSIONING AND TOLERANCING IN ACCORDANCE WITH ASME Y14.5M-1994

ALL DIMENSIONS ARE IN INCHES

TOLERANCES: X.X ± .100, X.XX ± .020, X.XXX ± .005, ANGLES ± 0°30'

DO NOT SCALE DRAWING

SURFACE FINISH

THIRD ANGLE PROJECTION

TREATMENT:

MATERIAL:

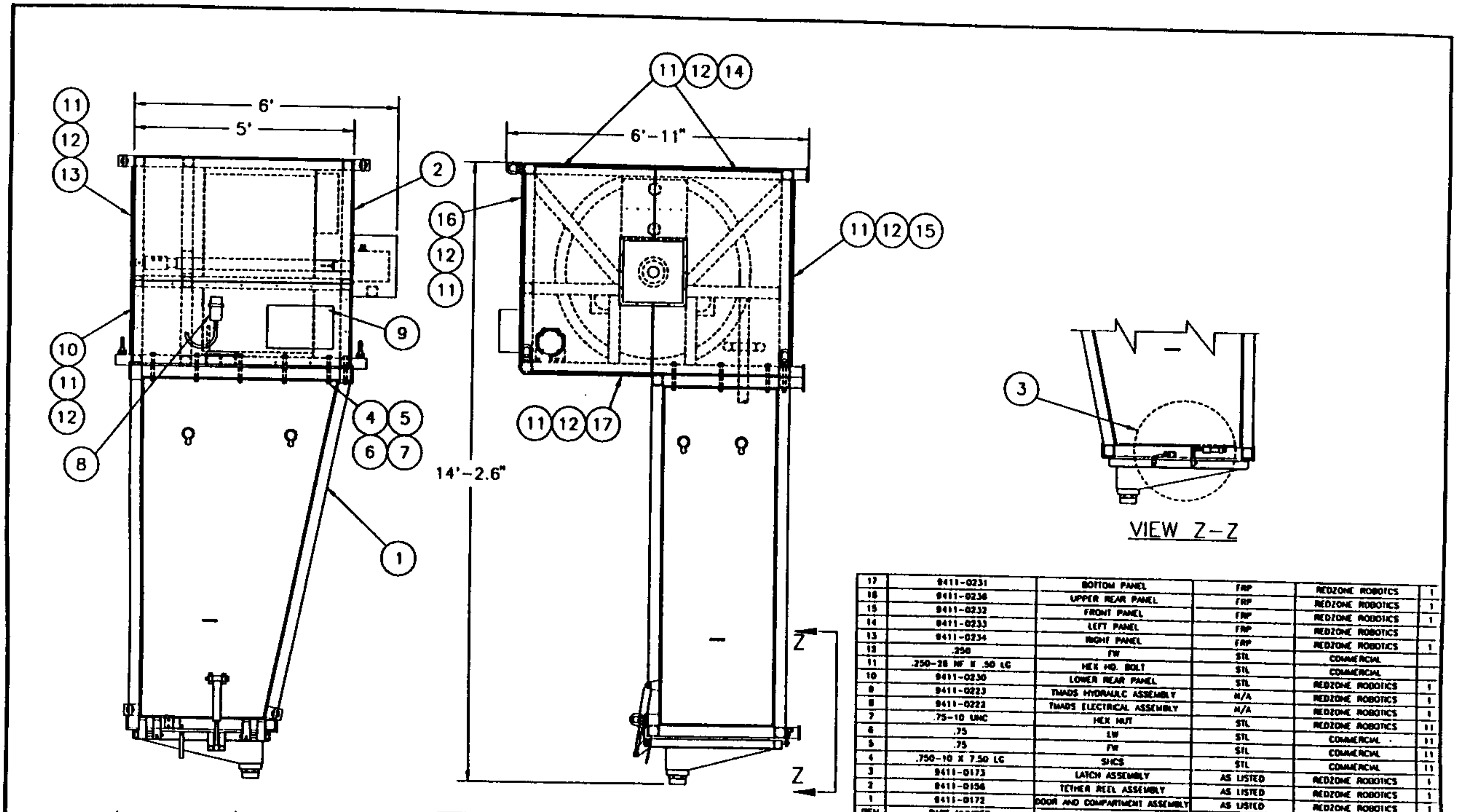
| AUTHORIZATION | | |
|---|---|---|
| DFTG: | B.B. | 2/9/96 |
| DSGNR: | | |
| CHKR: | | |
| ENGR: | | |
| APP: | | |
| APP: | | |

REDZONE ROBOTICS, INC.
2425 LIBERTY AVENUE
PITTSBURGH, PA 15222-4639
412-765-3064

HOUDINI ROBOT ASSY

CAGE CODE | SIZE B | 9411-0121

SCALE: 1/8 | WEIGHT: | SHEET 1 OF



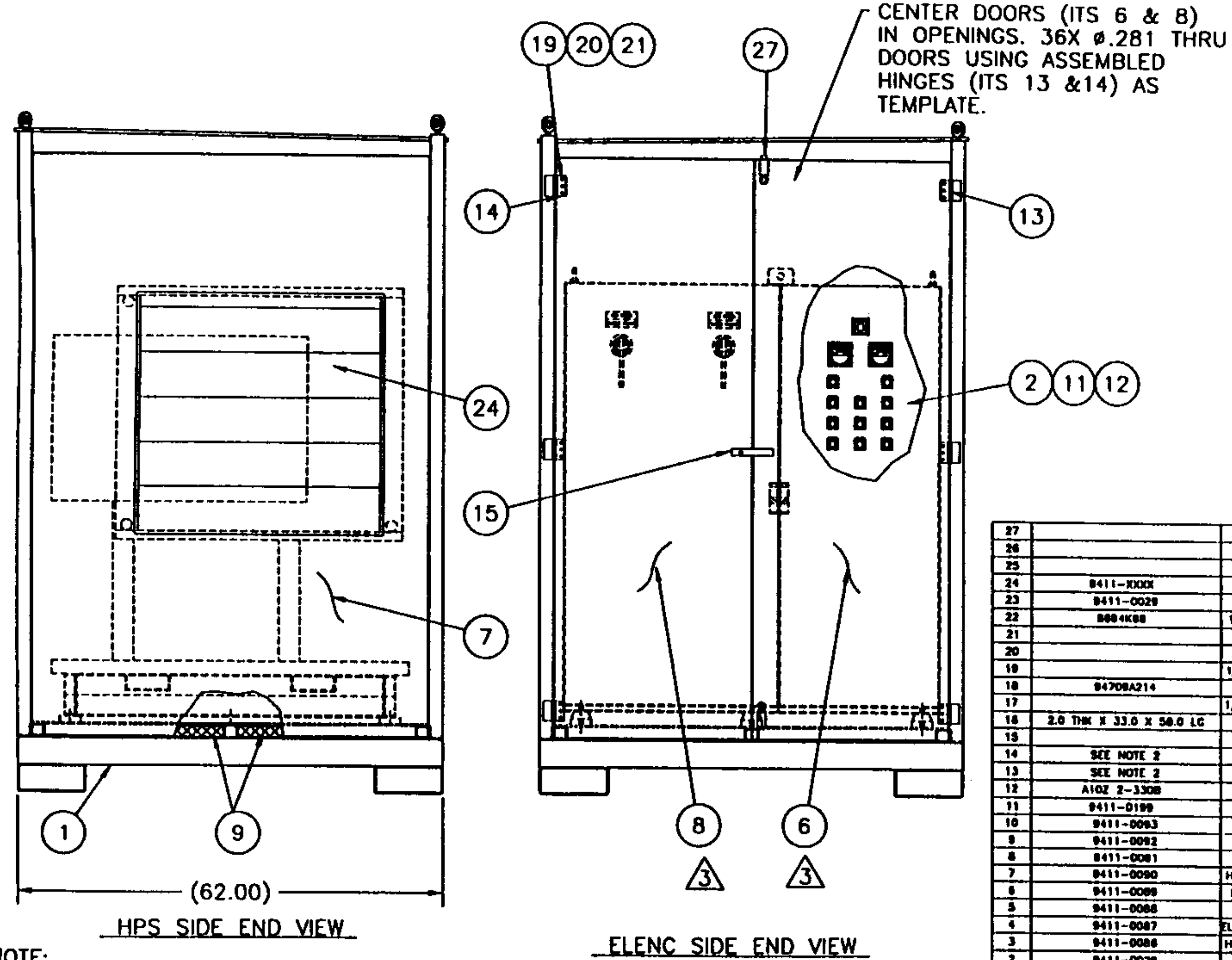

| ITEM | PART NUMBER | DESCRIPTION | MATERIAL | MANUFACTURER | QTY |
|---|---|---|---|---|---|
| 17 | 9411-0231 | BOTTOM PANEL | FRP | REDZONE ROBOTICS | 1 |
| 16 | 9411-0236 | UPPER REAR PANEL | FRP | REDZONE ROBOTICS | 1 |
| 15 | 9411-0232 | FRONT PANEL | FRP | REDZONE ROBOTICS | 1 |
| 14 | 9411-0233 | LEFT PANEL | FRP | REDZONE ROBOTICS | |
| 13 | 9411-0234 | RIGHT PANEL | FRP | REDZONE ROBOTICS | 1 |
| 12 | .250 | FW | STL | COMMERCIAL | |
| 11 | .250-28 NF X .50 LG | HEX HD. BOLT | STL | COMMERCIAL | |
| 10 | 9411-0230 | LOWER REAR PANEL | STL | REDZONE ROBOTICS | 1 |
| 9 | 9411-0223 | TMADS HYDRAULIC ASSEMBLY | N/A | REDZONE ROBOTICS | 1 |
| 8 | 9411-0222 | TMADS ELECTRICAL ASSEMBLY | N/A | REDZONE ROBOTICS | 1 |
| 7 | .75-10 UNC | HEX NUT | STL | REDZONE ROBOTICS | 11 |
| 6 | .75 | LW | STL | COMMERCIAL | 11 |
| 5 | .75 | FW | STL | COMMERCIAL | 11 |
| 4 | .750-10 X 7.50 LG | SHCS | STL | COMMERCIAL | 11 |
| 3 | 9411-0173 | LATCH ASSEMBLY | AS LISTED | REDZONE ROBOTICS | 1 |
| 2 | 9411-0156 | TETHER REEL ASSEMBLY | AS LISTED | REDZONE ROBOTICS | 1 |
| 1 | 9411-0172 | DOOR AND COMPARTMENT ASSEMBLY | AS LISTED | REDZONE ROBOTICS | 1 |

* UNLESS OTHERWISE NOTED *

- ALL DIMENSIONS ARE IN INCHES
- TOLERANCES X.X ±0.100, X.XX ±0.015, X.XXX ±0.005
- ANGLES ±1/2 DEG
- REMOVE ALL BURRS AND BREAK ALL SHARP EDGES TO .015 MAX.
- FILLET RADII-0.030 MAX.
- DIAMETERS ON A COMMON CENTER LINE CONCENTRIC WITHIN 0.005 T.I.R.
- SQUARENESS AND PARALLELISM OF SURFACES 0.002 PER INCH TO A MAX. OF 0.012 FOR SINGLE SURFACE.
- MACHINED SURFACE FINISH 125

| | | | |
|---|---|---|---|
| MAT'L: AS LISTED | | REDZONE ROBOTICS, INC. 2425 LIBERTY AVENUE PITTSBURGH, PA 15222-4639 412-765-3064 | |
| DESIGNED BY: AGF | DATE: 2/9/96 | ©REDZONE ROBOTICS, INC UNCLASSIFIED UNLESS OTHERWISE NOTED | |
| APPROVED BY: | DATE: | DRAWING NAME: TMADS ASSEMBLY | |
| DISTR: | SCALE: NONE | | |
| ECN: N/A | REVISION: A | DRAWING/PART NO: 9411-0105 | |

TMADS ASSEMBLY




NOTE:

1. DIMENSIONS AND TOLERANCING IN ACCORDANCE WITH ANSI Y14.5M-1982

2. SEE PDCU ENCLOSURE 9411-0045 FOR MODIFIED LIFT OFF SIDE OF DOOR HINGE.

3. ASSEMBLE PANELS WITH EXTERIOR SURFACE (SMOOTH SIDE) OUTWARD.

| ITEM | PART NUMBER | DESCRIPTION | MATERIAL | MANUFACTURER | QTY |
|---|---|---|---|---|---|
| 27 | | DOOR BOLT | VARIOUS | | 2 |
| 26 | | LOUVER ASSEMBLY | VARIOUS | | 2 |
| 25 | | VENT ASSEMBLY | VARIOUS | | 1 |
| 24 | 9411-XXXX | HPS ASSEMBLY | VARIOUS | REDZONE ROBOTICS | 1 |
| 23 | 9411-0029 | ELECTRONICS ENCLOSURE | VARIOUS | REDZONE ROBOTICS | 1 |
| 22 | 8604K88 | 1"(W) X 1/8"(T) WEATHER STRIP | SPONGE RUBBER | MCMASTER-CARR | 3 ROLLS |
| 21 | | 1/4-20 NUT | S.S. | MCMASTER-CARR | 36 |
| 20 | | 1/4-20 LOCK WASHER | S.S. | MCMASTER-CARR | 36 |
| 19 | | 1/4-20 X 3-1/2 SOCKET CAP SCREW | S.S. | MCMASTER-CARR | 36 |
| 18 | 94709A214 | SEALING WASHER | S.S./NEOPRENE | MCMASTER-CARR | 32 |
| 17 | | 1/4-20 X 1 SOCKET CAP SCREW | S.S. | MCMASTER-CARR | 32 |
| 16 | 2.0 THK X 33.0 X 50.0 LG | INSULATION | FOAM | COMMERICAL | 2 |
| 15 | | DOOR HANDLE/ LATCH | S.S | MCMASTER-CARR | 1 |
| 14 | SEE NOTE 2 | LEFT LIFT-OFF HINGE | S.S | REDZONE ROBOTICS | |
| 13 | SEE NOTE 2 | RIGHT LIFT-OFF HINGE | S.S | REDZONE ROBOTICS | |
| 12 | A10Z 2-3308 | SHOCK MOUNTS | VARIOUS | STOCK DRIVE PRODUCTS | 8 |
| 11 | 9411-0199 | ELEC. ENC. MOUNTING PLATE | STEEL | REDZONE ROBOTICS | 1 |
| 10 | 9411-0093 | PDCU ROOF | FRP | REDZONE ROBOTICS | 1 |
| 9 | 9411-0092 | PDCU FLOOR INSULATION | FRP | REDZONE ROBOTICS | 2 |
| 8 | 9411-0091 | LEFT DOOR ASSEMBLY | FRP | REDZONE ROBOTICS | 2 |
| 7 | 9411-0090 | HPS SIDE RIGHT DOOR ASSEMBLY | FRP | REDZONE ROBOTICS | 1 |
| 6 | 9411-0089 | ELENC SIDE RIGHT DOOR ASSEMBLY | FRP | REDZONE ROBOTICS | 1 |
| 5 | 9411-0088 | SIDE PANEL ASSEMBLY | FRP | REDZONE ROBOTICS | 2 |
| 4 | 9411-0087 | ELENC INLET SIDE PANEL ASSEMBLY | FRP | REDZONE ROBOTICS | 1 |
| 3 | 9411-0086 | HPS INLET SIDE PANEL ASSEMBLY | FRP | REDZONE ROBOTICS | 1 |
| 2 | 9411-0029 | ELECTRONICS ENCLOSURE ASSY | VARIOUS | REDZONE ROBOTICS | 1 |
| 1 | 9411-0045 | PDCU ENCLOSURE FRAME | STEEL | REDZONE ROBOTICS | 1 |

* UNLESS OTHERWISE NOTED *

- ALL DIMENSIONS ARE IN INCHES
- TOLERANCES X.X ±0.100, X.XX ±0.015, X.XXX ±0.005
- ANGLES ±1/2 DEG
- REMOVE ALL BURRS AND BREAK ALL SHARP EDGES TO .015 MAX.
- FILLET RADII-0.030 MAX.
- DIAMETERS ON A COMMON CENTER LINE CONCENTRIC WITHIN 0.005 T.I.R.
- SQUARENESS AND PARALLELISM OF SURFACES 0.002 PER INCH TO A MAX. OF 0.012 FOR SINGLE SURFACE.
- MACHINED SURFACE FINISH 125

MAT'L: AS LISTED
DESIGNED BY: JFB | DATE: 1-2-96
APPROVED BY: | DATE:
DISTR: | SCALE: NONE
ECN: N/A | REVISION: B

REDZONE ROBOTICS, INC.
2425 LIBERTY AVENUE
PITTSBURGH, PA 15222-4639
412-765-3064

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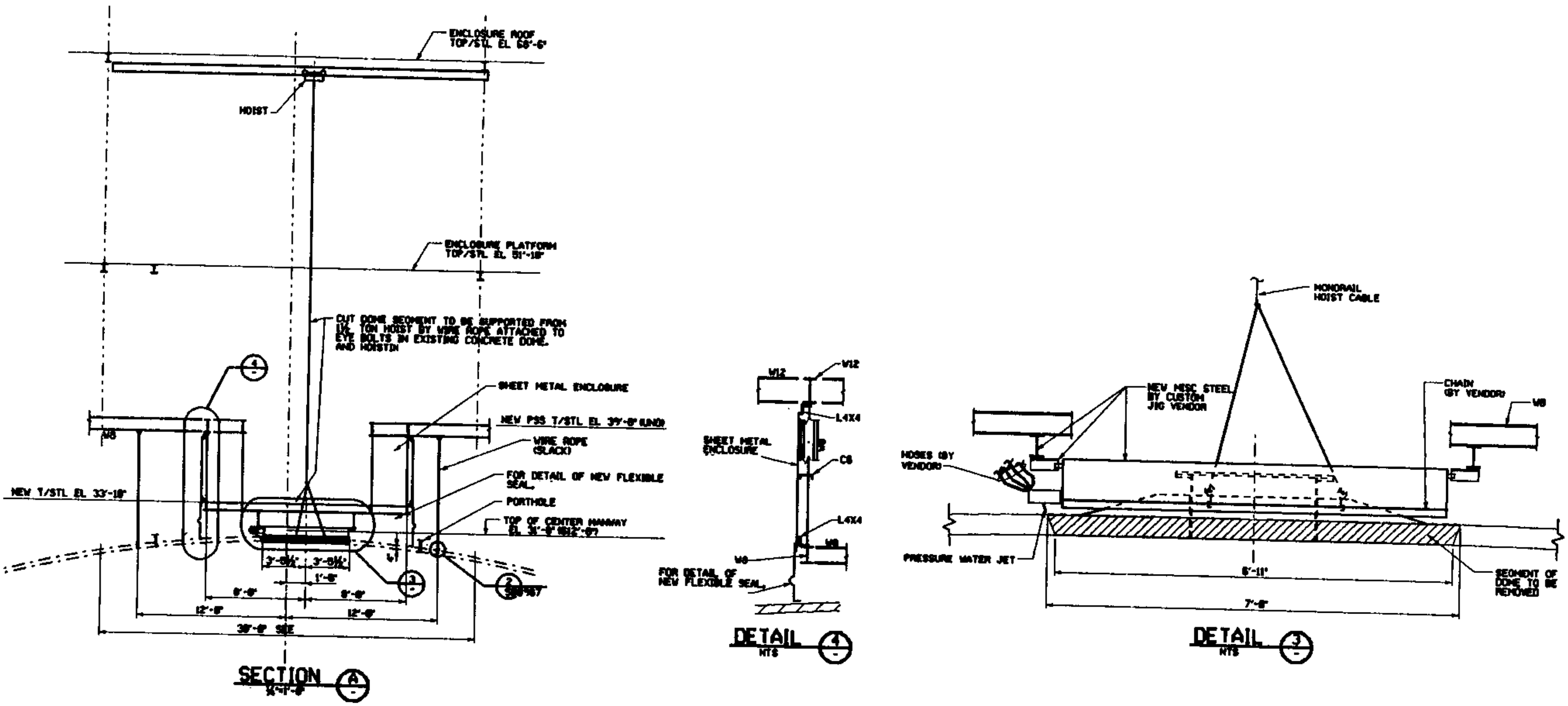
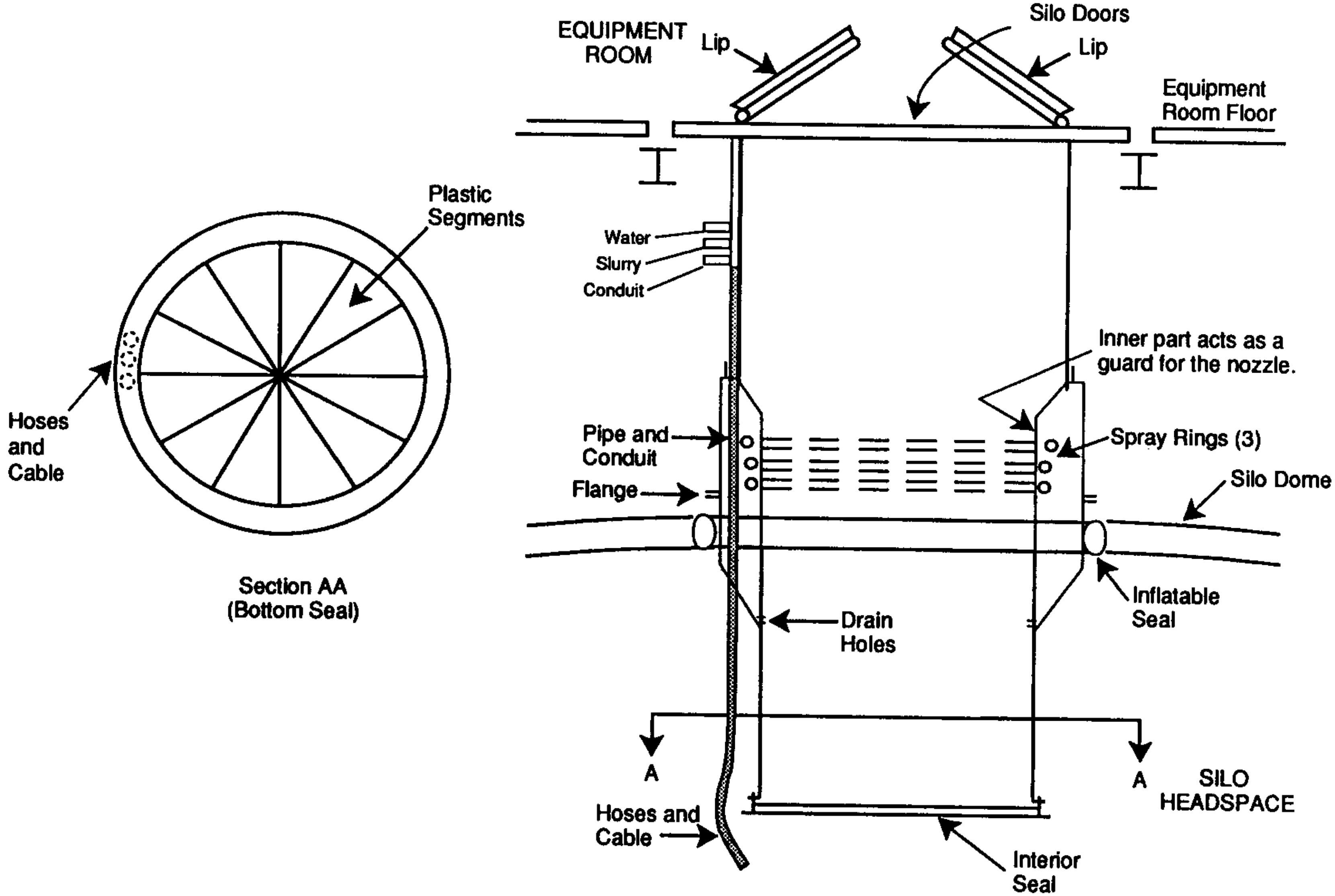
DRAWING NAME: PDCU ASSEMBLY
DRAWING/PART NO: 9411-0080
SHEET 1 OF 3

PDCU ASSEMBLY




DOME CUTTING AND
SEGMENT REMOVAL

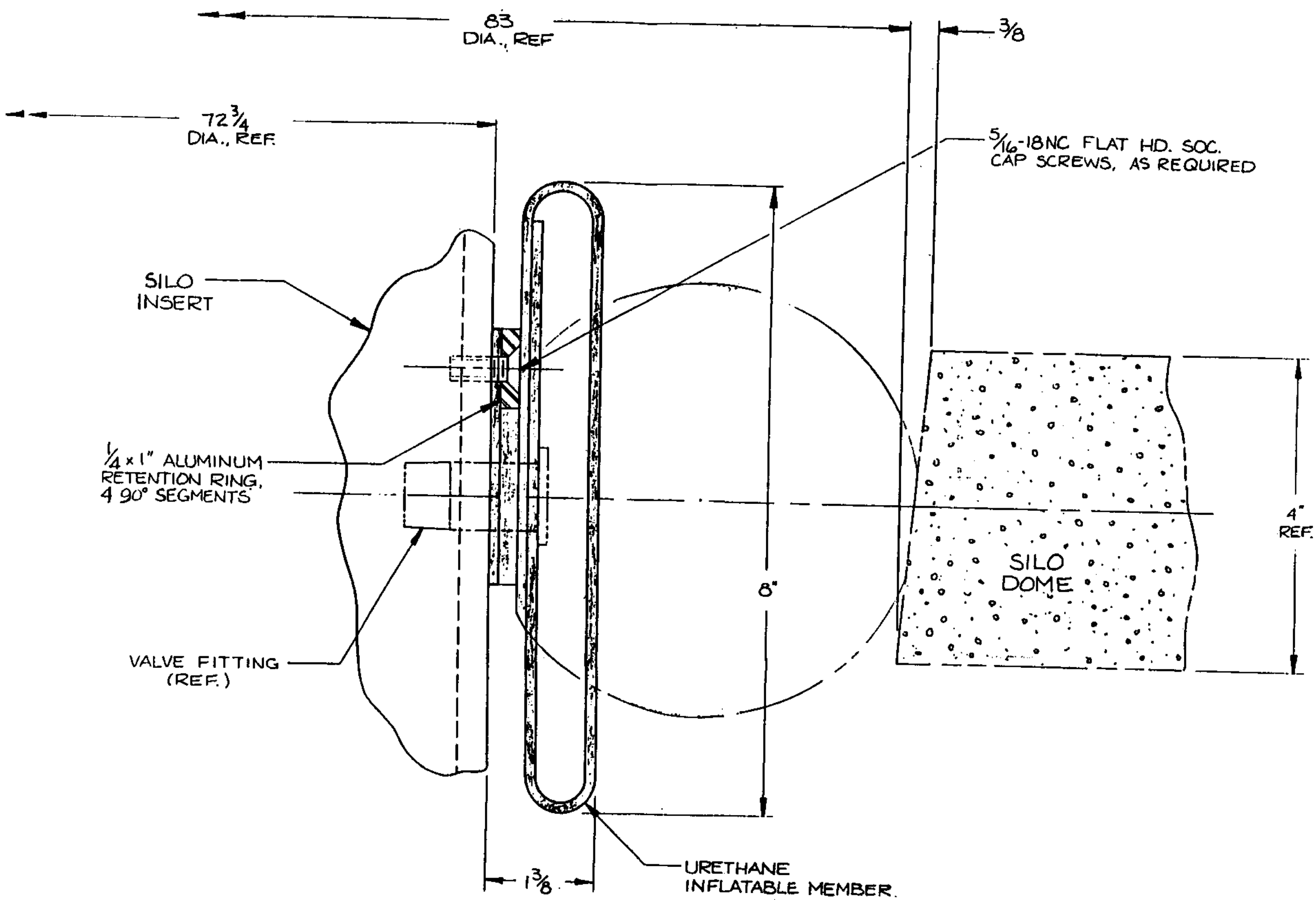
*ILLUS\OU-4\PO-161\ER SILO INSERT.EPS



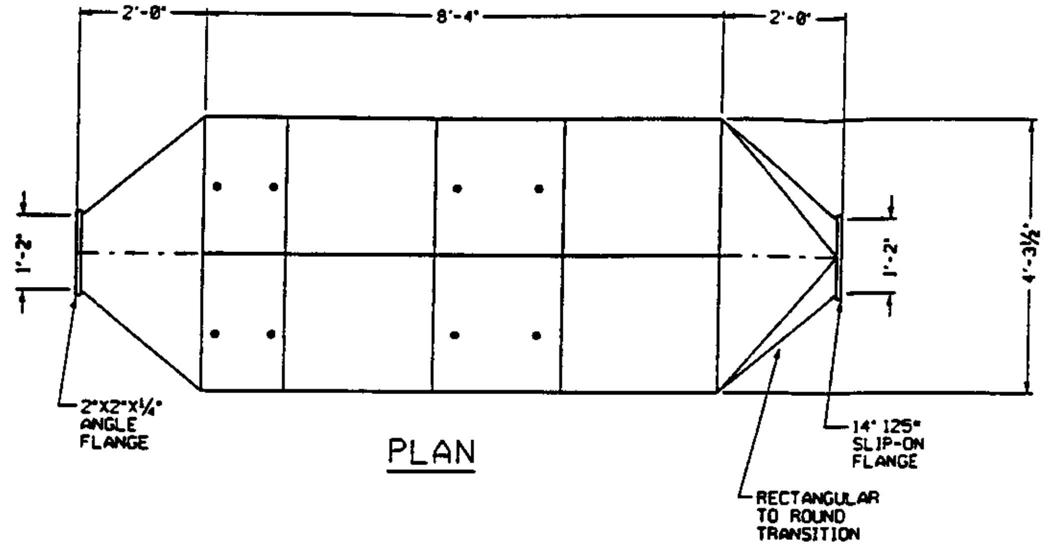

SILO CONTAINMENT INSERT B-12

NOT TO SCALE

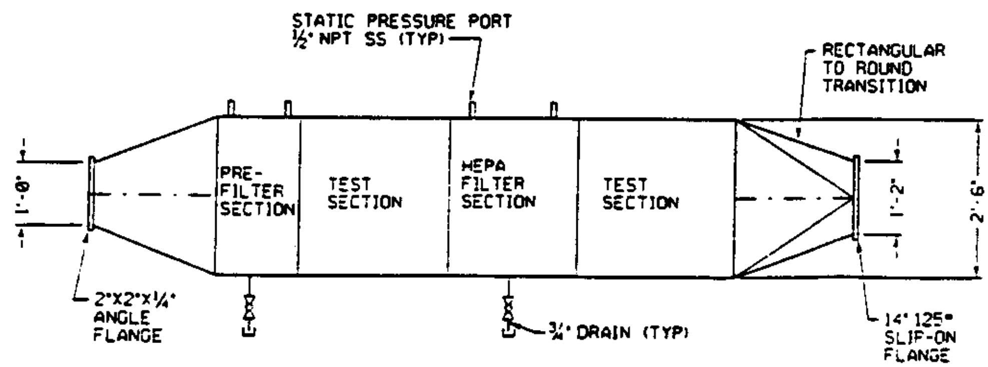
March 25, 1996



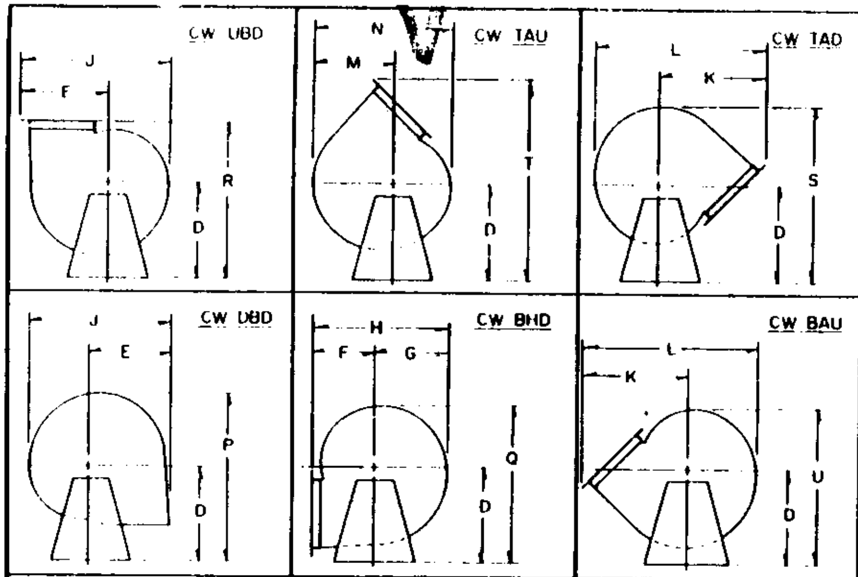

SILO INSERT
INFLATABLE SEAL




PLAN




ELEVATION




## NOTES:

1. CW ROTATION SHOWN. CCW ROTATION SIMILAR BUT OPPOSITE.
2. FOR MOTOR FRAME LARGER THAN MAXIMUM, USE CONSTRUCTION NO.2
3. ALL UNITS ARE NON-ROTATABLE.
4. HOUSING MATERIAL: 921, 10 GA. SIDES & SCROLL 923-929, 7 GA. SIDES & SCROLL.
5. ARRANGEMENT NO. 1 IS SHOWN. ARRANGEMENT NO. 9 MOTOR IS MOUNTED ON SIDE OF PEDESTAL.
6. DISCHARGE ANGLES MUST BE SUBTRACTED FROM E & J DIMENSION ON DBD.

| SIZE | UNIT NO. | ROT. | DISCH | MTR HP | T S |
|---|---|---|---|---|---|
| CFM. | S.P. | RPM. | BHP. | O.V. | |

ACCESSORIES REQ'D

RBO, RBA, RBW ARRG. NO. 1 & 9 IND. FANS

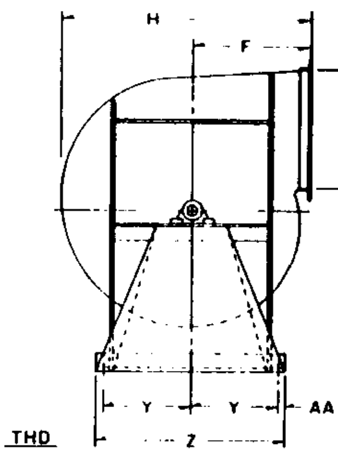
TWIN CITY FAN & BLOWER
MINNEAPOLIS, MINNESOTA 55414

DRAWN: 11-17-81
REVISED:
DRG. NO.: AC-8411

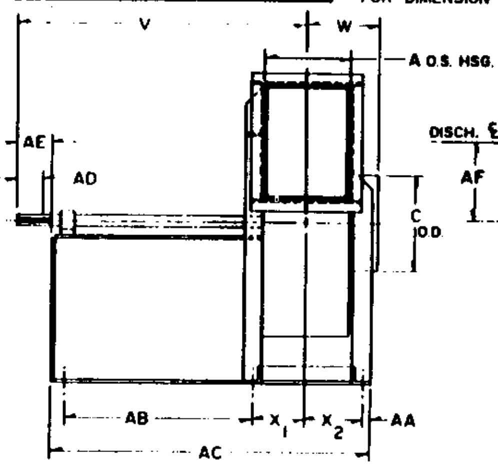
JOB
LOC.
CONT.
ENG/ARCH
S.O. NO.

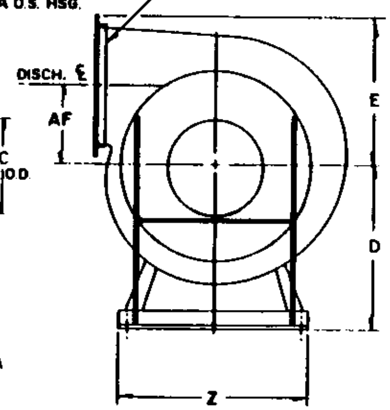
WHERE FLANGED INLET IS USED, SEE DWG. NO. BS-8790 FOR DIMENSION "W".

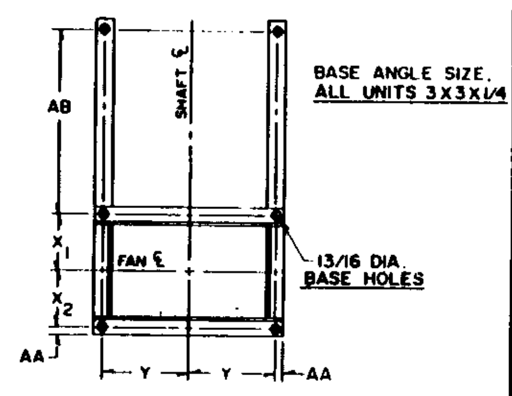
DISCHARGE ANGLES:
921 & 923, 2 X 2 X 1/4
926 & 929, 2-1/2 X 2-1/2 X 1/4




THD




BASE ANGLE SIZE, ALL UNITS 3 X 3 X 1/4

BASE PLAN

| SIZE | WHL DIA | A | B | C | D | E | F | G | H | SD SFT | SD KWY | HD SFT | HD KWY | J | K | L | M | N | P | O | R | S | T | U | V | W | X1 | X2 | Y | Z | AA | AB | AC | AD | AE | AF | MAX MTR FR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 921 | 36 1/2 | 17 13/16 | 20 | 21 1/4 | 34 1/2 | 33 1/4 | 23 1/2 | 28 1/2 | 52 | 2 7/16 | 5/8 x 5/16 | 2 11/16 | 5/8 x 5/16 | 59 | 40 1/8 | 67 1/4 | 29 7/8 | 54 1/4 | 63 | 60 1/8 | 58 | 64 3/8 | 74 5/8 | 58 7/8 | 45 3/16 | 12 1/8 | 10 9/16 | 10 3/4 | 17 1/8 | 37 | 1 3/8 | 25 1/4 | 49 9/16 | 7 | 7 3/4 | 21 1/4 | 324T |
| 923 | 40 | 19 5/8 | 22 | 23 3/8 | 37 1/2 | 36 5/16 | 26 1/2 | 31 1/4 | 57 3/4 | 2 11/16 | 5/8 x 5/16 | 2 15/16 | 3/4 x 3/8 | 64 1/2 | 44 7/16 | 74 3/16 | 32 13/16 | 59 7/16 | 68 3/4 | 65 11/16 | 64 | 70 5/16 | 81 15/16 | 64 3/16 | 48 5/16 | 13 | 11 7/16 | 11 [illegible] | 18 5/8 | 40 | 1 3/8 | 26 3/4 | 52 13/16 | 7 1/2 | 8 1/2 | 23 5/16 | 326T |
| 926 | 45 1/8 | 22 1/8 | 24 13/16 | 26 3/8 | 41 3/4 | 41 1/8 | 29 | 35 1/4 | 64 1/4 | 2 11/16 | 5/8 x 5/16 | 3 7/16 | 7/8 x 7/16 | 73 | 49 5/8 | 83 3/16 | 36 15/16 | 67 1/8 | 77 | 73 5/8 | 70 3/4 | 78 11/16 | 91 3/8 | 71 15/16 | 51 5/16 | 14 1/4 | 12 11/16 | 12 7/8 | 20 7/8 | 44 1/2 | 1 3/8 | 27 3/4 | 56 5/16 | 8 | 9 1/4 | 26 1/4 | 364T |
| 929 | 50 1/2 | 24 5/8 | 27 11/16 | 29 3/8 | 46 1/2 | 45 13/16 | 31 3/4 | 39 1/2 | 71 1/4 | 2 15/16 | 3/4 x 3/8 | 3 7/16 | 7/8 x 7/16 | 81 7/16 | 54 7/8 | 92 7/16 | 41 3/8 | 75 1/8 | 86 | 82 3/16 | 78 1/4 | 67 7/8 | 101 3/8 | 80 1/4 | 53 9/16 | 15 1/2 | 13 15/16 | 14 1/4 | 23 3/8 | 49 1/2 | 1 3/8 | 28 3/4 | 59 11/16 | 8 | 9 1/4 | 29 1/2 | 365T |

**RUSKIN®**

PO BOX 129 Grandview, Mo. 64030

# CD30VG1 and CD30VG2 HEAVY DUTY CONTROL DAMPERS

## GALVANIZED STEEL

### STANDARD CONSTRUCTION

**FRAME**
5" x 1" x 16 gage galvanized steel hat channel with corner braces.

**BLADES**
16 gage galvanized steel triple-V-groove blades, 8" maximum width.

**LINKAGE**
Face linkage in airstream.

**AXLES**
CD30VG1 — ½" diameter plated steel.
CD30VG2 — ¾" diameter plated steel.

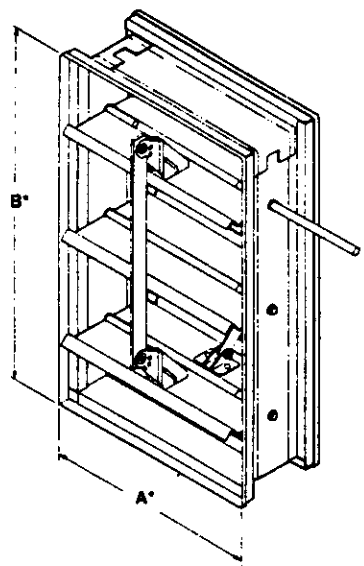
**BEARINGS**
Stainless steel.

**FINISH**
Mill galvanized.

**MAXIMUM TEMPERATURE**
250°F is standard. Damper can be supplied for temperatures between 250°F and 400°F by increasing clearance between blade ends and frame. Advise Ruskin of maximum operating temperature.

**MINIMUM SIZE**
Single blade, parallel action — 5"w x 5"h.
Two blade, parallel or opposed action — 8"w x 14"h.

**MAXIMUM SIZE**
Single section — 48"w x 72"h.
Multiple section assembly — Unlimited size.

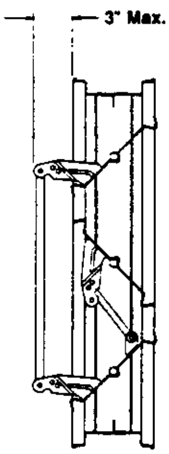



### FEATURES AND VARIATIONS

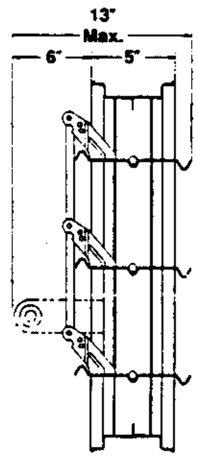
The CD30VG1 and CD30VG2, which install within the duct, are ideally suited to airflow modulation and shutoff in industrial applications.

These dampers can be designed and fabricated to meet many specifications and design requirements based on pressure, velocity, and environmental conditions. Design variations and special features available at additional cost include:

- Flexible stainless steel jamb seals.
- EPDM blade seals suitable for 250°F maximum temperature and silicone blade seals suitable for 400°F maximum temperature.
- Special materials and all stainless steel construction.
- Heavier 14 gage blade construction.
- Electric and pneumatic damper motor operators.




Opposed Blade




Parallel Blade

**WRIGHT®**
*Work-rated*
Electric Wire Rope Hoists
Issued 12-3-90

# Standard Headroom Parallel Mounted
# Frame 30
**2 Part Single Reeving-7/16"**

# 3 TON

For Pricing See Page 5s

| MODEL NUMBER | LIFT (FT) | SINGLE SPEED FPM | SINGLE SPEED B | SINGLE SPEED HP | TWO SPEED FPM | TWO SPEED B | TWO SPEED HP | C | HOOK TRAVEL U | HOOK TRAVEL L | $T_1$ | $T_2$ | DRUM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W3W3S 20-22 *2S | 20 | 22 | 24-7/8 | 5 | 22-7 | 24-7/8 | 5:1-2/3 | 28-1/8 | 2-1/2 | 1-1/2 | — | — | 1 |
| W3W3S 20-30 *2S | 20 | 30 | 24-7/8 | 6-1/4 | 30-10 | 27-1/4 | 6-1/4:2 | 28-1/8 | 2-1/2 | 1-1/2 | — | — | 1 |
| W3W3S 32-22 *2S | 32 | 22 | 27-1/8 | 5 | 22-7 | 27-1/8 | 5:1-2/3 | 30-3/8 | 4-1/8 | 2-1/4 | — | — | 2 |
| W3W3S 32-30 *2S | 32 | 30 | 27-1/8 | 6-1/4 | 30-10 | 29-1/2 | 6-1/4:2 | 30-3/8 | 4-1/8 | 2-1/4 | — | — | 2 |
| W3W3S 52-22 *2S | 52 | 22 | 30-7/8 | 5 | 22-7 | 30-7/8 | 5:1-2/3 | 34-1/8 | 7-7/8 | 2-1/4 | 8 | 7-3/4 | 3 |
| W3W3S 52-30 *2S | 52 | 30 | 30-7/8 | 6-1/4 | 30-10 | 33-1/4 | 6-1/4:2 | 34-1/8 | 7-7/8 | 2-1/4 | 8 | 7-3/4 | 3 |
| W3W3S 69-22 *2S | 69 | 22 | 34-3/8 | 5 | 22-7 | 34-3/8 | 5:1-2/3 | 37-5/8 | 11-3/8 | 2-1/4 | 11-1/2 | 11-1/4 | 4 |
| W3W3S 69-30 *2S | 69 | 30 | 34-3/8 | 6-1/4 | 30-10 | 36-3/4 | 6-1/4:2 | 37-5/8 | 11-3/8 | 2-1/4 | 11-1/2 | 11-1/4 | 4 |
| W3W3S 84-22 *2S | 84 | 22 | 37-3/8 | 5 | 22-7 | 37-3/8 | 5:1-2/3 | 40-5/8 | 14-3/8 | 2-1/4 | 14-1/2 | 14-1/4 | 5 |
| W3W3S 84-30 *2S | 84 | 30 | 37-3/8 | 6-1/4 | 30-10 | 39-3/4 | 6-1/4:2 | 40-5/8 | 14-3/8 | 2-1/4 | 14-1/2 | 14-1/4 | 5 |
| W3W3S 108-22 *2S | 108 | 22 | 41-7/8 | 5 | 22-7 | 41-7/8 | 5:1-2/3 | 45-1/8 | 18-7/8 | 2-1/4 | 19 | 18-3/4 | 6 |
| W3W3S 108-30 *2S | 108 | 30 | 41-7/8 | 6-1/4 | 30-10 | 44-1/4 | 6-1/4:2 | 45-1/8 | 18-7/8 | 2-1/4 | 19 | 18-3/4 | 6 |

All dimensions shown in inches unless otherwise specified. Dimensions which change with beam size are for minimum beam shown.

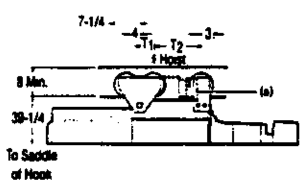
*Work-rated* trolleys are adjustable for Standard I beam or WF beam, 4 inch to 8 inch flange width. Beam size must be specified. Trolleys are also available for 3.25 or 3.33" patented track beams. Trolleys for WF beams with flange widths greater than 8 inches available on application.

All reference to beam flange widths are for clearance purposes only and do not imply that lower flange of beam will support hoist with load.

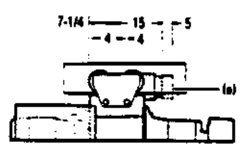
| TROLLEY DATA: | Speed | 65 FPM | 125 FPM |
|---|---|---|---|
| | HP | 1/2 | 1/2 |

All two speed trolley motors are 1800/600 RPM.
(a) Optional Trolley Brake.

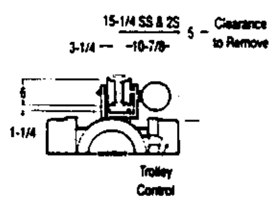
**52, 69, 84, 108 Foot Lifts**
**Wheel Dia. 5**




**20, 32 Foot Lifts**

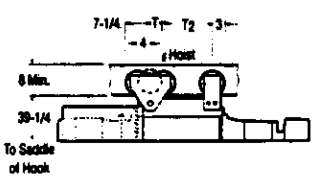


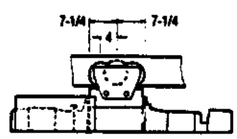

**All Lifts**

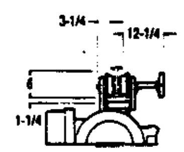



## Motorized Trolley

**Wheel Dia. 5**



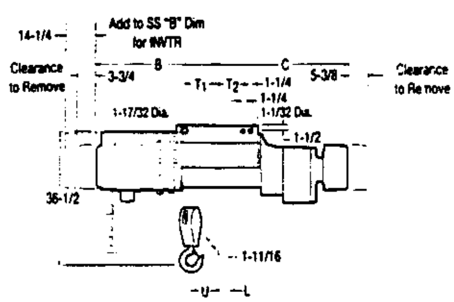



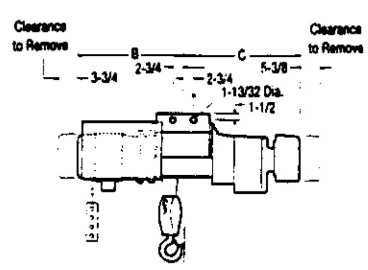



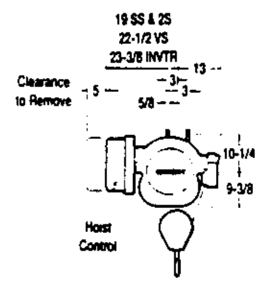

**▲ WARNING**

Equipment described herein is not designed for, and should not be used for, lifting, supporting, or transporting humans. Modifications to upgrade, rerate, or otherwise alter the hoist or crane equipment shall be authorized only by the original manufacturer or qualified professional engineer. Failure to comply with any one of the limitations noted herein may result in serious bodily injury.

## Plain or Geared Trolley




## Lug Mounted

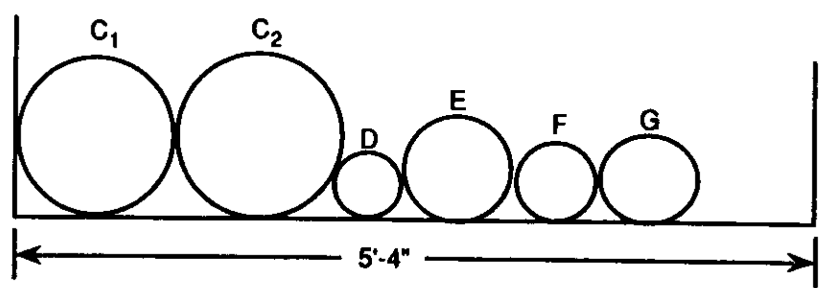


TILT HOIST

ILLUS\OU-4\PO-161\PIPE RACK DETAILS.EPS

| LINE NO. | SERVICE | DESCRIPTION | APPROXIMATE OVERALL DIAMETER | WT. Lb/L IN FT |
|---|---|---|---|---|
| $C_1$ | Slurry Line | Double Wall, Insulated and Heat Traced | 11" | 34 |
| $C_2$ | Water Return Line | Double Wall, Insulated and Heat Traced | 11" | 33 |
| D | Breathing Air Line | 1" Pipe SCH.40 | 1.315" | 3 |
| E | Instrument Air/Plant Air Line | 2" Pipe SCH.40 | 2.375" | 5 |
| F | Hydraulic Fluid Line | 1" Pipe | 1.315" | 3 |
| G | Potable Water Line | Insulated and Heat Traced | 5 " | 4 |

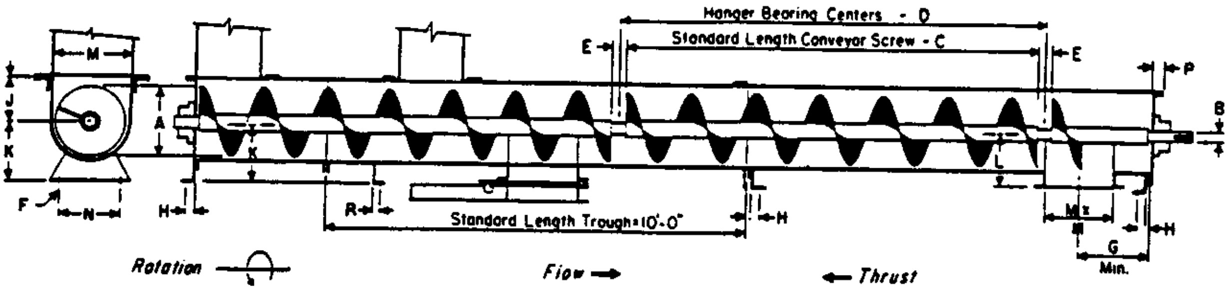
NOTE: All values in this table are preliminary and are intended for estimating purposes only.




PIPE RACK DETAILS

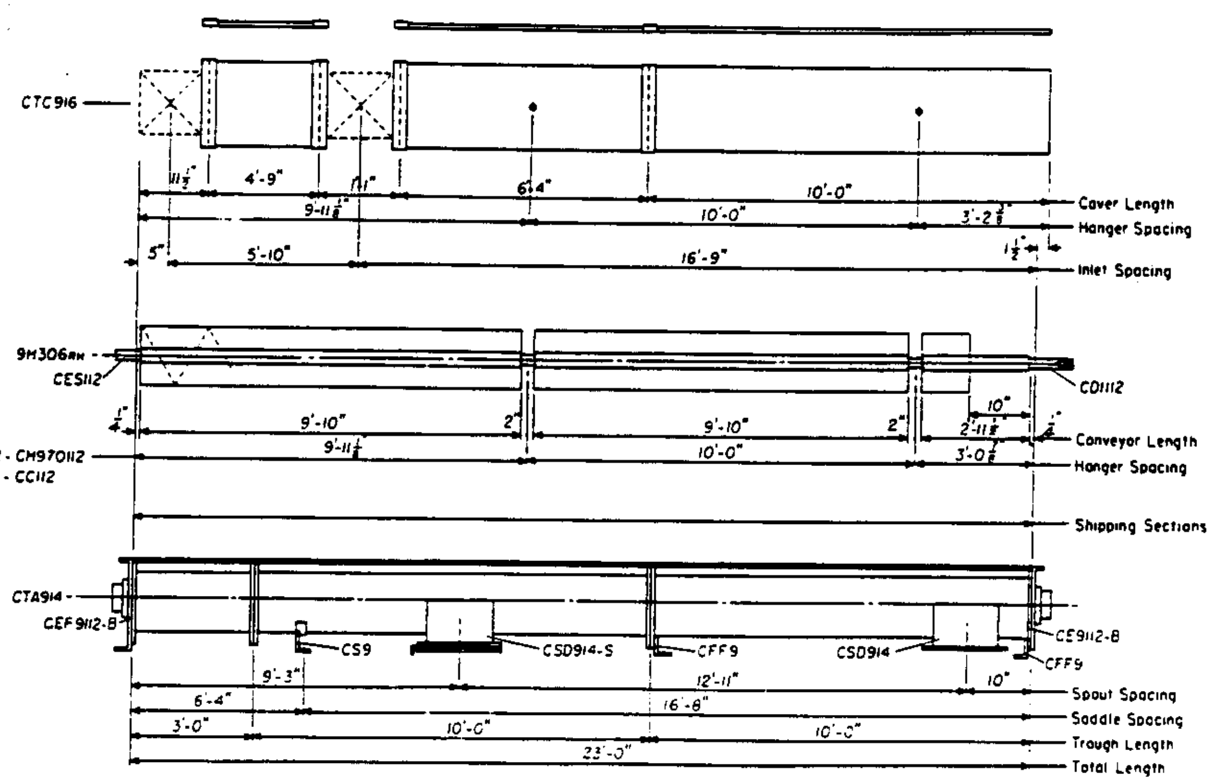
NOT TO SCALE

March 21, 1996

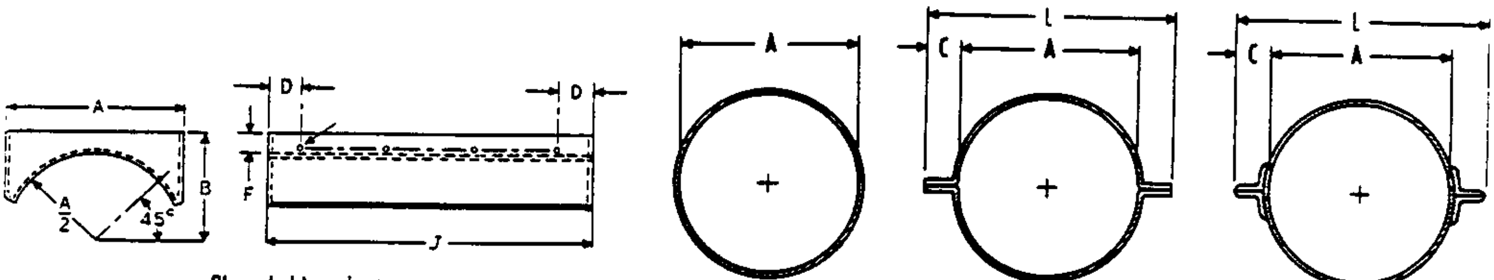



| A Screw Diam. | B Cplng. Diam. | C Length Ft.-In. | D Length In Ft. | E | F | G | H | J | K | L | M | N | P | R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 1 | 7-10 1/2 | 8 | 1 1/2 | 3/8 | 4 1/2 | 1 | 3 5/8 | 4 5/8 | 3 3/4 | 5 | 5 3/4 | 1 1/2 | 7/8 |
| 6 | 1 1/2 | 9-10 | 10 | 2 | 5/8 | 6 | 1 | 4 1/2 | 5 5/8 | 5 | 7 | 8 1/8 | 1 1/2 | 11/16 |
| 9 | 1 1/2 | 9-10 | 10 | 2 | 1/2 | 8 | 1 1/2 | 6 1/8 | 7 7/8 | 7 1/8 | 10 | 9 3/8 | 1 5/8 | 1 1/16 |
| | 2 | 9-10 | 10 | 2 | 1/2 | 8 | 1 1/2 | 6 1/8 | 7 7/8 | 7 1/8 | 10 | 9 3/8 | 1 5/8 | 1 1/16 |
| 10 | 1 1/2 | 9-10 | 10 | 2 | 5/8 | 9 | 1 3/4 | 6 3/8 | 8 7/8 | 7 7/8 | 11 | 9 1/2 | 1 3/4 | 1 1/4 |
| | 2 | 9-10 | 10 | 2 | 5/8 | 9 | 1 3/4 | 6 3/8 | 8 7/8 | 7 7/8 | 11 | 9 1/2 | 1 3/4 | 1 1/4 |
| 12 | 2 | 11-10 | 12 | 2 | 5/8 | 10 1/2 | 1 5/8 | 7 3/4 | 9 5/8 | 8 7/8 | 13 | 12 1/4 | 2 | 1 3/8 |
| | 2 7/16 | 11-9 | 12 | 3 | 5/8 | 10 1/2 | 1 5/8 | 7 3/4 | 9 5/8 | 8 7/8 | 13 | 12 1/4 | 2 | 1 3/8 |
| | 3 | 11-9 | 12 | 3 | 5/8 | 10 1/2 | 1 5/8 | 7 3/4 | 9 5/8 | 8 7/8 | 13 | 12 1/4 | 2 | 1 3/8 |
| 14 | 2 7/16 | 11-9 | 12 | 3 | 5/8 | 11 1/2 | 1 5/8 | 9 1/4 | 10 7/8 | 10 1/8 | 15 | 13 1/2 | 2 | 1 3/8 |
| | 3 | 11-9 | 12 | 3 | 5/8 | 11 1/2 | 1 5/8 | 9 1/4 | 10 7/8 | 10 1/8 | 15 | 13 1/2 | 2 | 1 3/8 |
| 16 | 3 | 11-9 | 12 | 3 | 5/8 | 13 1/2 | 2 | 10 5/8 | 12 | 11 1/8 | 17 | 14 7/8 | 2 1/2 | 1 3/4 |
| 18 | 3 | 11-9 | 12 | 3 | 5/8 | 14 1/2 | 2 | 12 1/8 | 13 3/8 | 12 3/8 | 19 | 16 | 2 1/2 | 1 3/4 |
| | 3 7/16 | 11-8 | 12 | 4 | 5/8 | 14 1/2 | 2 | 12 1/8 | 13 3/8 | 12 3/8 | 19 | 16 | 2 1/2 | 1 3/4 |
| 20 | 3 | 11-9 | 12 | 3 | 3/4 | 15 1/2 | 2 1/4 | 13 1/2 | 15 | 13 3/8 | 21 | 19 1/4 | 2 1/2 | 2 |
| | 3 7/16 | 11-8 | 12 | 4 | 3/4 | 15 1/2 | 2 1/4 | 13 1/2 | 15 | 13 3/8 | 21 | 19 1/4 | 2 1/2 | 2 |
| 24 | 3 7/16 | 11-8 | 12 | 4 | 3/4 | 17 1/2 | 2 1/2 | 16 1/2 | 18 1/8 | 15 3/8 | 25 | 20 | 2 1/2 | 2 1/4 |

## suggested method of detailing



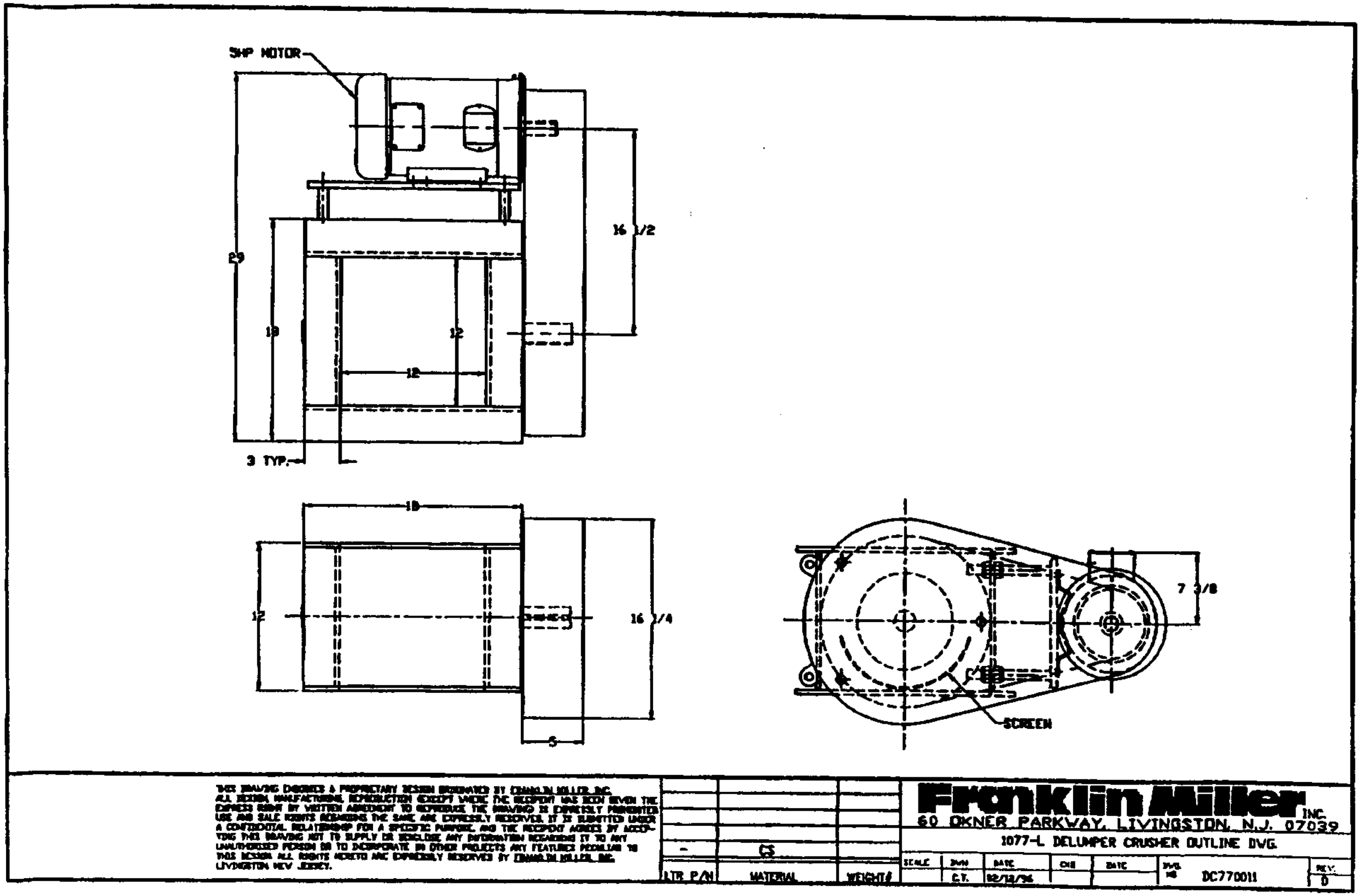
# tubular housing




Shrouded trough cover | Tubular housing | Flanged tubular housing | Angle flanged tubular housin

| Con-veyor Diam. | Trough Thick-ness | Shrouded Trough Cover Part Number | Shrouded Trough Cover Wt. | Tubular Housing Part Number | Tubular Housing Weight 10 Ft. | Tubular Housing Weight 5 Ft. | Flanged Tubular Housing Part Number | Flanged Tubular Housing Weight 10 Ft. | Flanged Tubular Housing Weight 5 Ft. | Angle Flanged Tubular Housing Part Number | Angle Flanged Tubular Housing Weight 10 Ft. | Angle Flanged Tubular Housing Weight 5 Ft. | A | B | C | L | D | E | S | T | P | J |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | ☐ 16 | CTS 416 | 2.0 | CHP 416 | 35 | 18 | CHF 416 | 43 | 22 | CHA 416 | 81 | 41 | 5 | 3 5/8 | 1 | 7 5/8 | 2 | 4 | 1 | 3/4 | 5/8 | 8 |
| | 14* | CTS 414 | | CHP 414 | 43 | 22 | CHF 414 | 53 | 27 | CHA 414 | 89 | 45 | | | | 7 [illegible] | | | | | | |
| | 12 | CTS 412 | | CHP 412 | 60 | 31 | CHF 412 | 74 | 38 | CHA 412 | 106 | 54 | | | | 7 3/4 | | | | | | |
| 6 | ☐ 16 | CTS 616 | | CHP 616 | 50 | 27 | CHF 616 | 60 | 32 | CHA 616 | 110 | 57 | 7 | 4 1/2 | 1 1/4 | 9 5/8 | 3 | 6 | 1 | 5/8 | 3/4 | 12 |
| | 14* | CTS 614 | 3.9 | CHP 614 | 62 | 33 | CHF 614 | 75 | 40 | CHA 614 | 122 | 63 | | | | 9 [illegible] | | | | | | |
| | 12* | CTS 612 | 5.4 | CHP 612 | 85 | 44 | CHF 612 | 103 | 53 | CHA 612 | 145 | 74 | | | | 9 3/4 | | | | | | |
| | 3/16 | CTS 67 | | CHP 67 | 145 | 74 | CHF 67 | 168 | 86 | CHA 67 | 205 | 104 | | | | 9 7/8 | | | | | | |
| 9 | 16 | CTS 916 | | CHP 916 | 72 | 39 | CHF 916 | 84 | 45 | CHA 916 | 144 | 75 | 10 | 6 1/4 | 1 1/2 | 13 5/8 | 3 | 6 | 2 | 5/8 | 3/4 | 15 |
| | ☐ 14* | CTS 914 | 7.8 | CHP 914 | 89 | 47 | CHF 914 | 104 | 55 | CHA 914 | 161 | 83 | | | | 13 [illegible] | | | | | | |
| | 12 | CTS 912 | | CHP 912 | 122 | 64 | CHF 912 | 143 | 75 | CHA 912 | 194 | 100 | | | | 13 3/4 | | | | | | |
| | 10 | CTS 910 | | CHP 910 | 155 | 80 | CHF 910 | 182 | 94 | CHA 910 | 227 | 116 | | | | 13 [illegible] | | | | | | |
| | 3/16* | CTS 97 | 19 | CHP 97 | 208 | 107 | CHF 97 | 245 | 126 | CHA 97 | 280 | 143 | | | | 13 5/8 | | | | | | |
| | 1/4 | CTS 93 | | CHP 93 | 275 | 140 | CHF 93 | 324 | 165 | CHA 93 | 347 | 176 | | | | 13 1/2 | | | | | | |
| 10 | 16 | CTS1016 | | CHP1016 | 79 | 42 | CHF1016 | 91 | 48 | CHA1016 | 151 | 78 | 11 | 6 5/8 | 1 1/2 | 14 [illegible] | 2 1/2 | 5 | 3 | 5/8 | 7/8 | 20 |
| | ☐ 14* | CTS1014 | 9.4 | CHP1014 | 97 | 52 | CHF1014 | 112 | 60 | CHA1014 | 169 | 88 | | | | 14 [illegible] | | | | | | |
| | 12 | CTS1012 | | CHP1012 | 133 | 70 | CHF1012 | 154 | 81 | CHA1012 | 205 | 106 | | | | 14 [illegible] | | | | | | |
| | 10 | CTS1010 | | CHP1010 | 169 | 88 | CHF1010 | 196 | 102 | CHA1010 | 241 | 124 | | | | 14 [illegible] | | | | | | |
| | 3/16* | CTS 107 | 23 | CHP 107 | 227 | 117 | CHF 107 | 264 | 136 | CHA 107 | 299 | 153 | | | | 14 5/8 | | | | | | |
| | 1/4 | CTS 103 | | CHP 103 | 301 | 154 | CHF 103 | 350 | 179 | CHA 103 | 373 | 190 | | | | 14 1/2 | | | | | | |
| | | | | | 12 Ft. | 6 Ft. | | 12 Ft. | 6 Ft. | | 12 Ft. | 6 Ft. | | | | | | | | | | |
| 12 | ☐ 12* | CTS1212 | 19 | CHP1212 | 195 | 103 | CHF1212 | 231 | 121 | CHA1212 | 313 | 162 | 13 | 7 3/4 | 2 | 17 3/4 | 3 | 6 | 3 | 5/8 | 1 1/4 | 24 |
| | 10 | CTS1210 | | CHP1210 | 248 | 130 | CHF1210 | 295 | 153 | CHA1210 | 366 | 189 | | | | 17 [illegible] | | | | | | |
| | 3/16* | CTS 127 | 33 | CHP 127 | 329 | 171 | CHF 127 | 392 | 202 | CHA 127 | 447 | 229 | | | | 17 5/8 | | | | | | |
| | 1/4 | CTS 123 | | CHP 123 | 434 | 223 | CHF 123 | 518 | 265 | CHA 123 | 552 | 282 | | | | 17 1/2 | | | | | | |
| 14 | ☐ 12* | CTS1412 | 26 | CHP1412 | 223 | 118 | CHF1412 | 259 | 137 | CHA1412 | 341 | 177 | 15 | 9 1/4 | 2 | 19 [illegible] | 3 1/2 | 7 | 3 | 5/8 | 1 1/4 | 28 |
| | 10 | CTS1410 | | CHP1410 | 282 | 148 | CHF1410 | 329 | 172 | CHA1410 | 400 | 207 | | | | 19 [illegible] | | | | | | |
| | 3/16* | CTS 147 | 47 | CHP 147 | 327 | 196 | CHF 147 | 441 | 227 | CHA 147 | 496 | 255 | | | | 19 5/8 | | | | | | |
| | 1/4 | CTS 143 | | CHP 143 | 498 | 256 | CHF 143 | 582 | 298 | CHA 143 | 616 | 315 | | | | 19 1/2 | | | | | | |
| 16 | ☐ 12* | CTS1612 | 35 | CHP1612 | 254 | 135 | CHF1612 | 290 | 153 | CHA1612 | 372 | 194 | 17 | 10 5/8 | 2 | 21 3/4 | 4 | 8 | 3 | 5/8 | 1 1/4 | 32 |
| | 10 | CTS1610 | | CHP1610 | 320 | 168 | CHF1610 | 367 | 191 | CHA1610 | 438 | 227 | | | | 21 [illegible] | | | | | | |
| | 3/16* | CTS 167 | 62 | CHP 167 | 428 | 222 | CHF 167 | 493 | 254 | CHA 167 | 546 | 281 | | | | 21 5/8 | | | | | | |
| | 1/4 | CTS 163 | | CHP 163 | 566 | 291 | CHF 163 | 650 | 333 | CHA 163 | 684 | 360 | | | | 21 1/2 | | | | | | |
| 18 | ☐ 12* | CTS1812 | 45 | CHP1812 | 290 | 156 | CHF1812 | 336 | 179 | CHA1812 | 437 | 229 | 19 | 12 1/8 | 2 1/2 | 24 3/4 | 4 1/2 | 9 | 3 | 5/8 | 1 3/8 | 36 |
| | 10 | CTS1810 | | CHP1810 | 378 | 193 | CHF1810 | 423 | 222 | CHA1810 | 511 | 266 | | | | 24 [illegible] | | | | | | |
| | 3/16* | CTS 187 | 79 | CHP 187 | 485 | 253 | CHF 187 | 566 | 294 | CHA 187 | 632 | 327 | | | | 24 5/8 | | | | | | |
| | 1/4 | CTS 183 | | CHP 183 | 639 | 331 | CHF 183 | 746 | 384 | CHA 183 | 786 | 404 | | | | 24 1/2 | | | | | | |
| 20 | ☐ 10* | CTS2010 | 71 | CHP2010 | 401 | 212 | CHF2010 | 458 | 241 | CHA2010 | 545 | 286 | 21 | 13 1/2 | 2 1/2 | 26 [illegible] | 4 | 8 | 4 | 5/8 | 1 3/8 | 40 |
| | 3/16* | CTS 207 | 99 | CHP 207 | 534 | 286 | CHF 207 | 612 | 318 | CHA 207 | 681 | 352 | | | | 26 5/8 | | | | | | |
| | 1/4 | CTS 203 | | CHP 203 | 702 | 363 | CHF 203 | 806 | 415 | CHA 203 | 849 | 437 | | | | 26 1/2 | | | | | | |
| 24 | ☐ 10* | CTS2410 | 104 | CHP2410 | 477 | 252 | CHF2410 | 534 | 281 | CHA2410 | 626 | 327 | 25 | 16 1/2 | 2 1/2 | 30 [illegible] | 4 | 8 | 5 | 3/4 | 1 3/8 | 48 |
| | 3/16* | CTS 247 | 144 | CHP 247 | 637 | 332 | CHF 247 | 713 | 370 | CHA 247 | 784 | 406 | | | | 30 5/8 | | | | | | |
| | 1/4 | CTS 243 | | CHP 243 | 837 | 432 | CHF 243 | 941 | 484 | CHA 243 | 986 | 507 | | | | 30 1/2 | | | | | | |

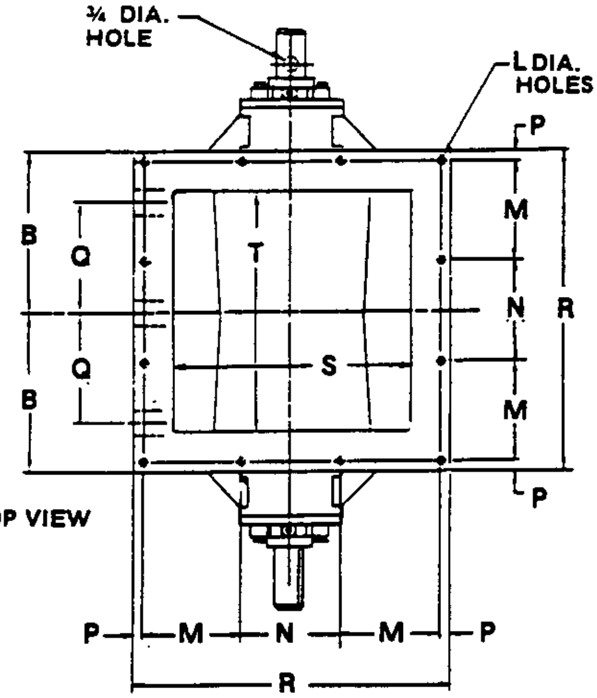
☐ Standard gauge.
* Standard shroud gage.



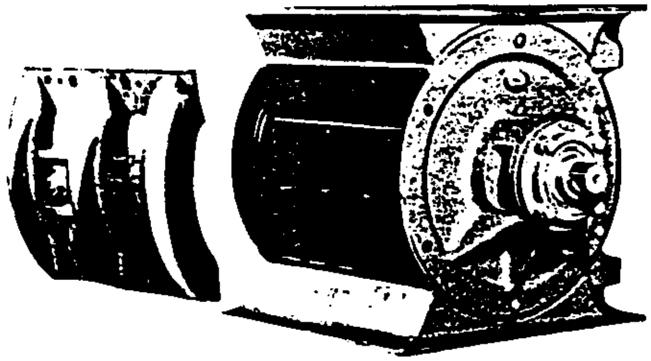

DELUMPER CRUSHER

Toll Free 800-821-2476

# MAC High Efficiency Airlock
## Bare Airlock




TOP VIEW



**STANDARD SPECIFICATIONS FOR MAC HIGH EFFICIENCY AIRLOCKS 7x7 THROUGH 18x18**

**Materials of Construction**

Cast gray iron housing & end plates/SS cast housing & end plates
Carbon steel rotor/SS rotor

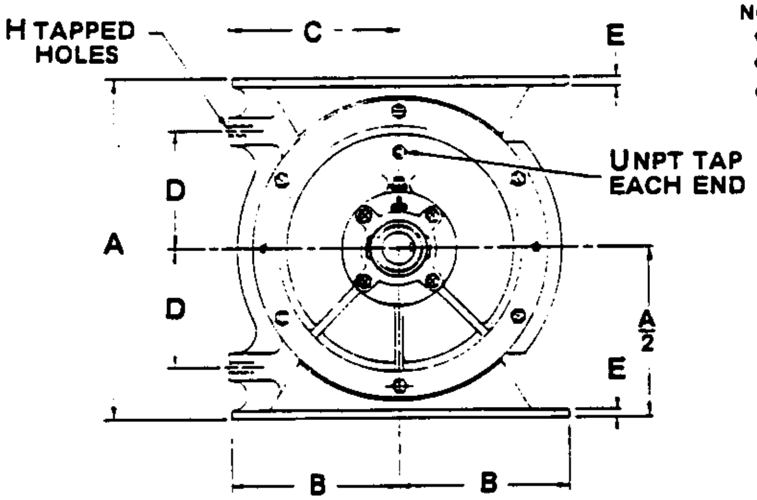
**Major Components**

Cast housing and inspection cover
Cast end plates complete with packing gland seals, teflon lantern ring, air purge and 4-bolt flanged bearing
Counter clockwise rotation from drive end

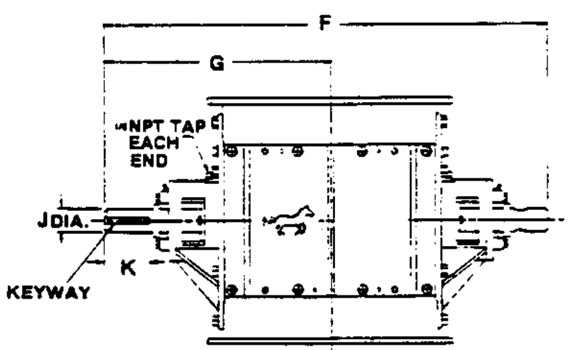
**Painting**

Standard cleaning and metal preparation
Primed with one coat 32x29 gray primer and one finish coat
Color to be specified
Standard color is MAC Blue

NOTES
① Bottom flange detail matches top flange detail.
② Normal rotation is CCW as seen from drive end.
③ Two ¼ thick nominal fnage gaskets included with airlock to provide seal at inlet and outlet flanges.



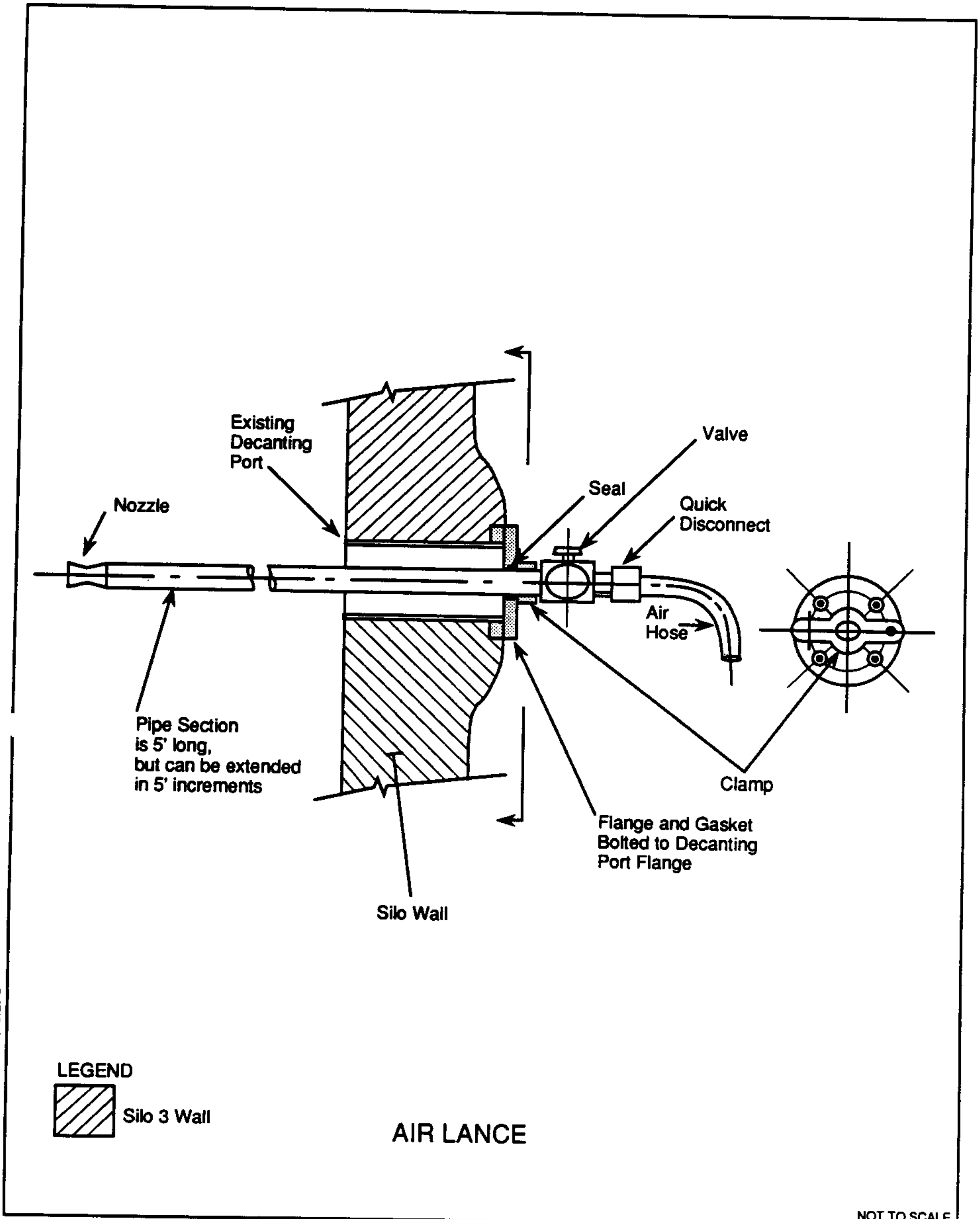

DRIVE END VIEW




INSPECTION SIDE VIEW

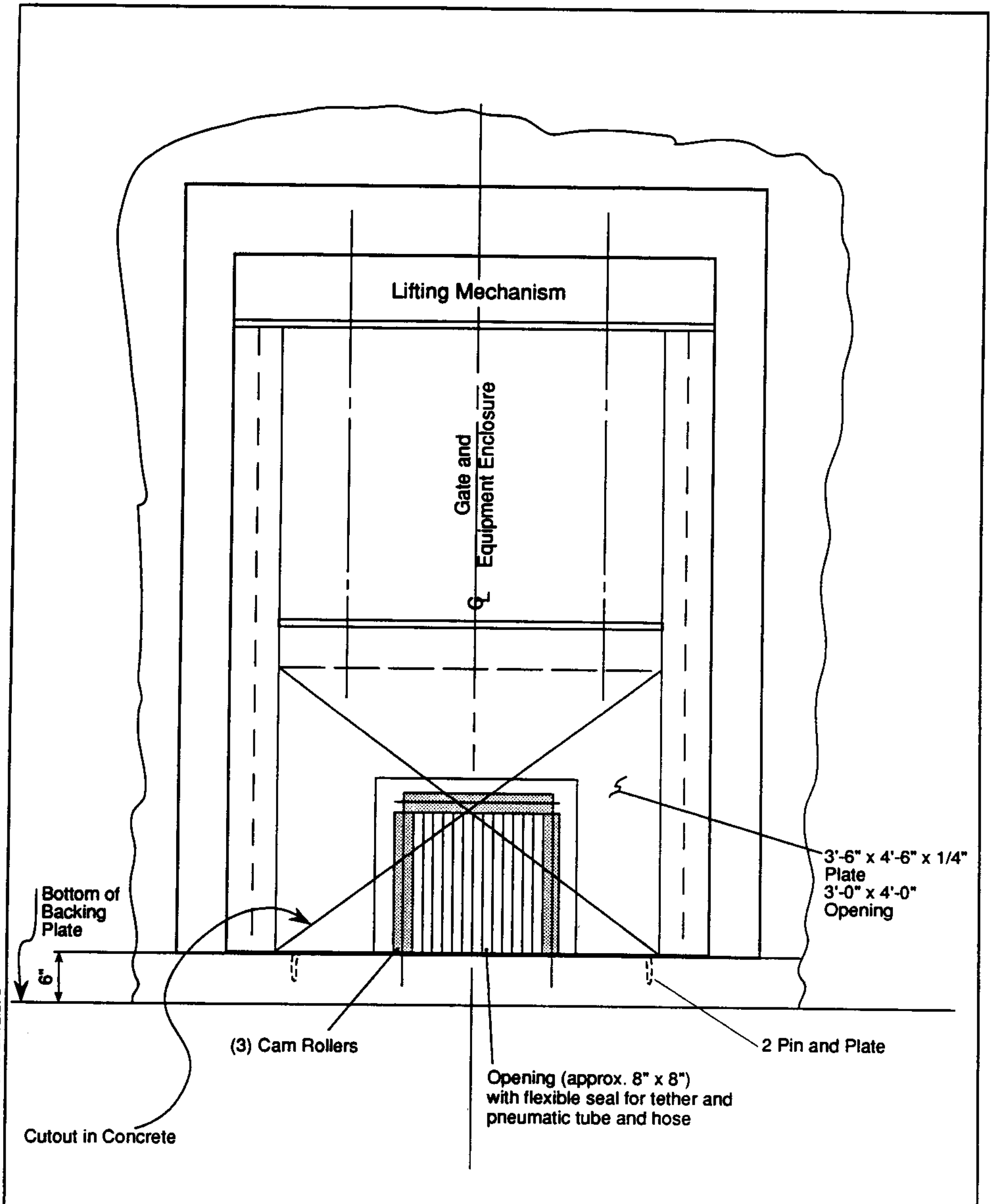
| Airlock Size | C.F.R. | A Stainless | A Gray Iron | B | C | D | E | F | G | H | J | K | L | M | N | P | Q | R | S | T | U | Keyway | Wt. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7x7 | .1 | 9.000 | 9.125 | 4 7/8 | 5 | 3 | 5/16 | 21¼ | 10 5/8 | (4) 3/8 -16 | 1¼ | 2 3/8 | 5/16 | 3 | 3 | 3/8 | 3¾ | 9¾ | 7 | 7 | 3/8 | ¼X 1/8 | 92 |
| 9x9 | 2 | 12.000 | 12 250 | 6 | 7 | 4 | 5/16 | 24¾ | 12¾ | (4) 3/8 -16 | 1½ | 3 3/16 | 3/8 | 3 5/8 | 3¾ | [illegible] | 4 1/8 | 12 | 8 | 8 | 3/8 | 3/8 X 3/16 | 161 |
| 12x12 | .6 | 16.000 | 16.500 | 8 | 8 | 5½ | 3/8 | 29 | 14 7/8 | (6) 3/8 -16 | 1½ | 3 3/16 | 7/16 | 5 | 5 | ½ | 5½ | 16 | 12 | 11¼ | ¾ | 3/8 X 3/16 | 314 |
| 15x15 | 1 2 | 18.000 | 18.500 | 10 | 10 | 6 | ½ | 33 | 16 7/8 | (6) 3/8 -16 | 1 15/16 | 3¼ | 7/16 | 6 1/8 | 6¼ | ¾ | 7 | 20 | 15¼ | 14½ | ¾ | ½x¼ | 490 |
| 18x18 | 2.0 | 24.000 | 24.000 | 12 | 12 | 6¼ | 5/8 | 36½ | 18 5/8 | (6)½ -13 | 2 3/16 | 3¼ | 9/16 | 7½ | 7½ | ¾ | 9 1/16 | 24 | 18 | 18 | ¾ | ½x¼ | 895 |

All Dimensions Are In Inches.




March 21, 1996

\\ILLUS\OU-4\PO-161\AIR LANCE.EPS



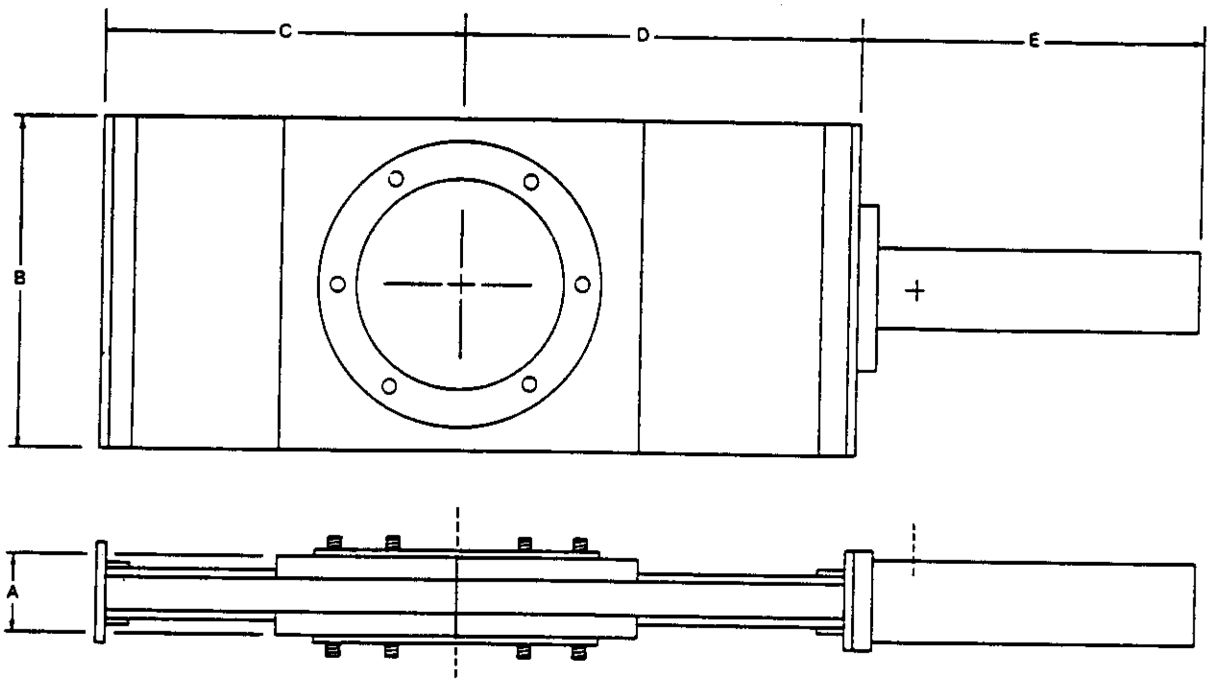

SLIDING GATE

NOT TO SCALE

March 26, 1996

## Knife Gates

**2, 3, 4, 5, 6, 8, 10 and 12-Inch Size**
**Bulk Material Knife Gates with Air Cylinder Actuator**




**Flange Gasket ¼ x F I.D. x G O.D.**
**Stud Bolts with Nuts 5/16-18 N.C. x 7/8, H Qty., Eq. Space on J Circle**

| Model | Size* | A | B | C | D | E | F | G | H | J | Wt. Lbs. | Nom. Free Flow Material Rate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B2-1 | 2 | 1¾ | 5 | 4½ | 6¼ | 6¼ | 2 | 4 | 4 | 3¼ | 10 | 60 CF/Hr. |
| B3-1 | 3 | 1¾ | 6 | 6 | 7¾ | 7¼ | 3 | 5 | 4 | 4¼ | 12 | 190 CF/Hr. |
| B4-1 | 4 | 1¾ | 7 | 7½ | 9¼ | 8¼ | 4 | 6 | 4 | 5¼ | 15 | 450 CF/Hr. |
| B5-1 | 5 | 2 | 9 | 9½ | 10¾ | 10½ | 5 | 7½ | 6 | 6½ | 25 | 1,000 CF/Hr. |
| B6-1 | 6 | 2 | 10 | 11 | 12½ | 11 | 6 | 8½ | 6 | 7½ | 30 | 1,500 CF/Hr. |
| B8-1 | 8 | 2 | 12 | 14 | 15½ | 13½ | 8 | 10½ | 8 | 9½ | 40 | 3,300 CF/Hr. |
| B10-1 | 10 | 2½ | 14 | 17 | 18½ | 15½ | 10 | 12½ | 8 | 11½ | 65 | 6,750 CF/Hr. |
| B12-1 | 12 | 2½ | 16 | 20 | 21¼ | 17½ | 12 | 15 | .12 | 13 13/16 | 80 | 16,250 CF/Hr. |

**Nominal Size—Orifice conforms to inside diameter of ⅛" wall OD tubing.*

- All dimensions are given in inches.
- 70 PSIG minimum air actuating pressure.
- 200 PSIG maximum air actuating pressure.
- Dry, filtered and lubricated actuating air recommended.
- Hole pattern straddles transverse centerlines.

# CORE BORE M-1 Drill Rig

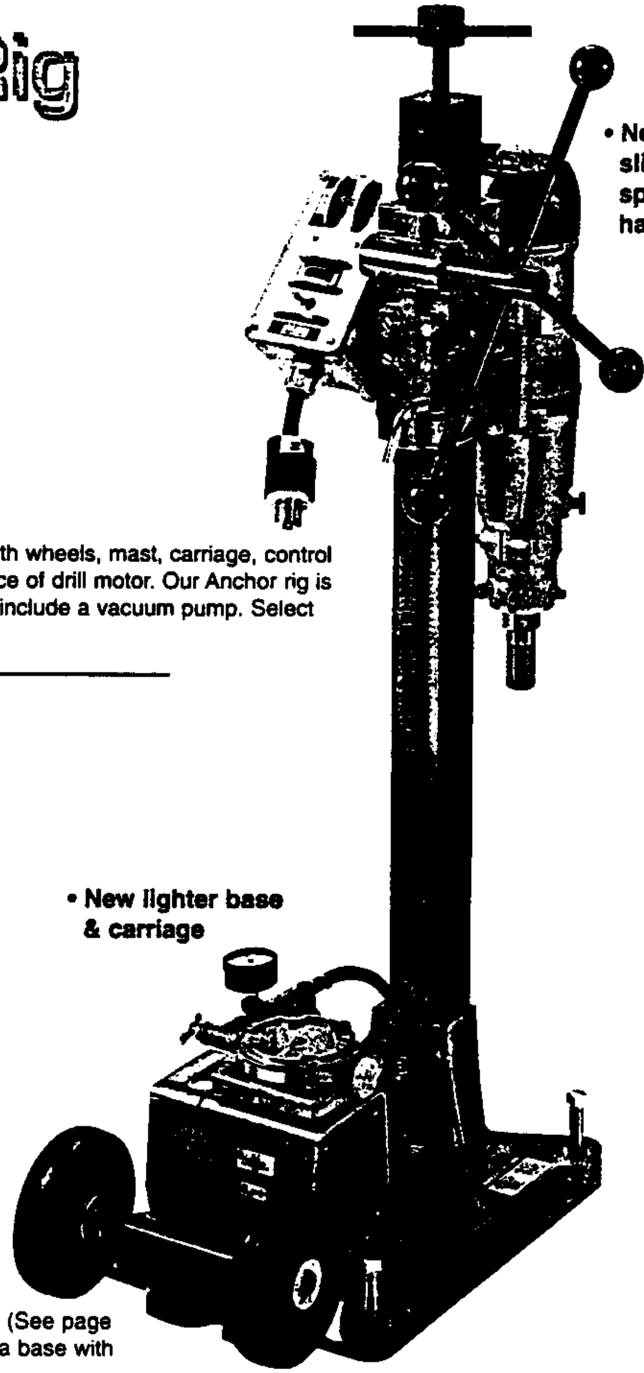
## "The #1 Drill Rig in America"

- Dual switch/outlet control panel & amp meter
- New 4 spoke handle
- Redesigned, lighter base and carriage
- 2 1/2" Square column with black oxidized finish
- Quick change over from vacuum to anchor base
- 10" Bit capacity-14" with one spacer
- 6" Wheels for better mobility

### Order Complete:

Our Combination rig includes a combination anchor/vacuum base with wheels, mast, carriage, control panel, vacuum pump, ceiling jack, motor mount plate and your choice of drill motor. Our Anchor rig is the same as above except for its smaller anchor base and does not include a vacuum pump. Select from P/N's listed below.

| Complete M-1 Drill Rigs | | | | |
|---|---|---|---|---|
| **Motor** | **RPM** | **Safety Override** | **Combo Rig P/N** | **Anchor Rig P/N** |
| 18 Amp B&D | 350/900 | Slip Clutch | 4245055 | 4245001 |
| 15 Amp B&D | 350/900 | Slip Clutch | 4245050 | 4245002 |
| 20 Amp Milw. | 300/600 | Slip Clutch | 4245048 | 4245009 |
| 20 Amp Milw. | 450/900 | Slip Clutch | 4245059 | 4245003 |
| 20 Amp Milw. | 600/1200 | Slip Clutch | 4245049 | 4245010 |
| 20 Amp Milw. | 450/900 | Shear Pin | 4245060 | 4245005 |
| 20 Amp Milw. | 600/1200 | Shear Pin | 4245061 | 4245004 |
| 15 Amp Milw. | 500/1000 | Shear Pin | 4245051 | 4245006 |
| 15 Amp Milw. | 375/750 | Shear Pin | 4245052 | 4245007 |
| 23 Amp WEKA | 300/640 960 | Slip Clutch | 4245053 | 4245008 |

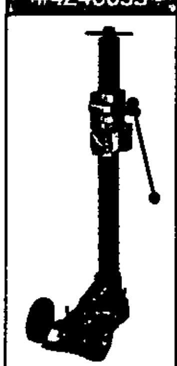
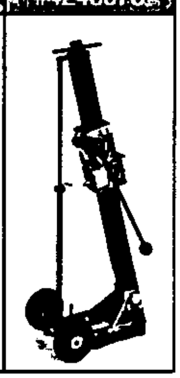


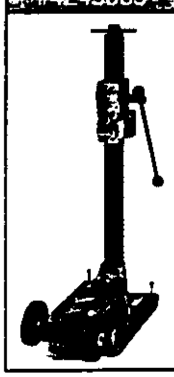

M-1 Complete Combination Rig

### Or, Build Your Own:

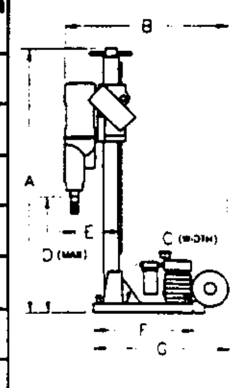
Select one of the drill stands shown below, add drill motor, control panel/on-off switch, and vacuum pump as required for your application (See page 5 for motor options and page 6 for accessories). Drill stands include a base with wheels, mast*, carriage, ceiling jack and motor mount plate.

*Call factory for special length masts

| Anchor Drill Stand | |
|---|---|
| Standard #4246055 | Angle #4246070 |
|  |  |

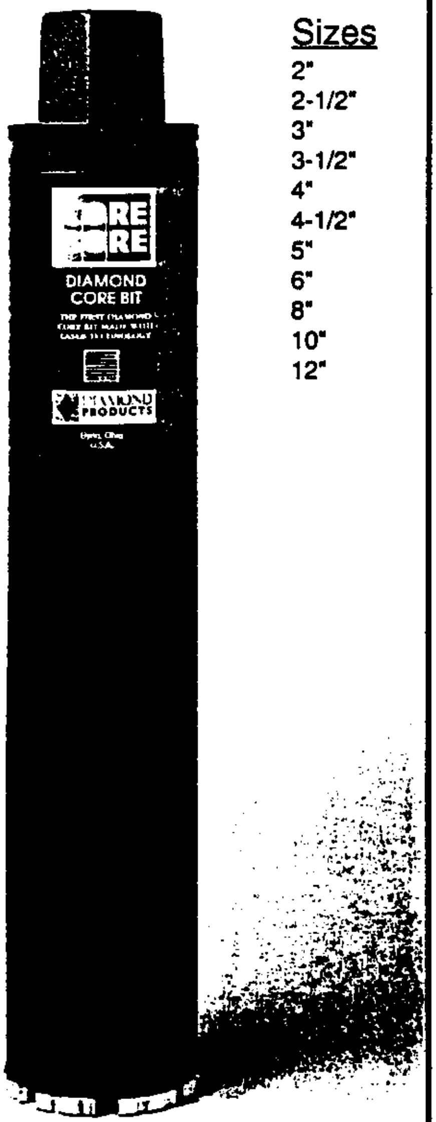
| Combination Drill Stand | |
|---|---|
| Standard #4245065 | Angle #4245062 |
|  |  |

| M-1 Drill Rig Dimensions | | |
|---|---|---|
| | **Anchor Stand** | **Combination Stand** |
| A. | 43-3/4" | 44-1/4" |
| B. | 23-1/2" | 28-1/2" |
| C. | 6" | 13-1/2" |
| D.* | 24-1/4" | 24-1/4" |
| E.* | 5-5/8" | 5-5/8" |
| F. | 11" | 17" |
| G. | 16" | 23" |



| PREMIUM BLACK TURBO BIT | H.D. ORANGE TURBO BIT |
|---|---|

## PREMIUM BLACK TURBO BIT




**Sizes**

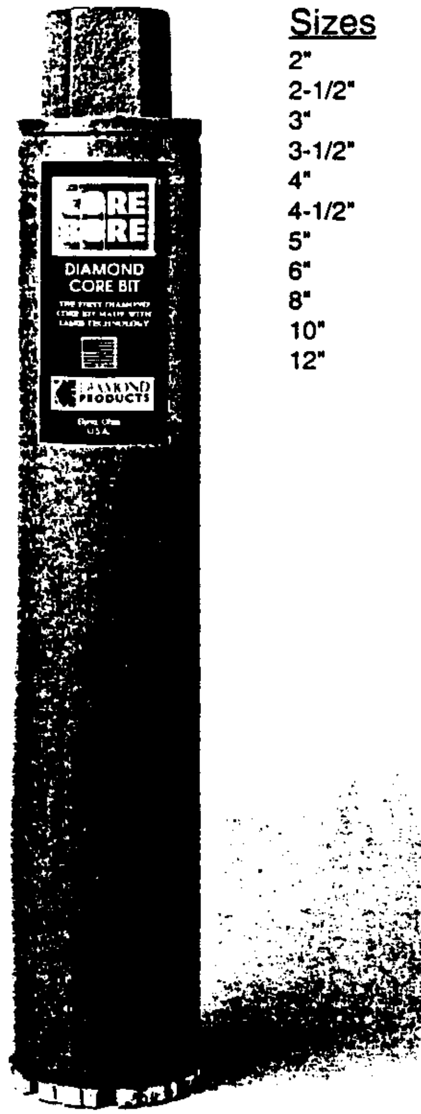
2"
2-1/2"
3"
3-1/2"
4"
4-1/2"
5"
6"
8"
10"
12"

The **Premium Black Turbo** is our most popular Turbo bit. It has a very high diamond concentration for excellent performance in heavy to very heavy steel applications. Combine this excellent diamond concentration with its fluted segment design and you have a bit that flies through just about anything.

**SPECIFICATIONS**

TP - General Purpose, High Steel

## H.D. ORANGE TURBO BIT




**Sizes**

2"
2-1/2"
3"
3-1/2"
4"
4-1/2"
5"
6"
8"
10"
12"

Our **Heavy Duty Orange Turbo** bit has very good diamond concentration for excellent speed in moderate to heavy steel applications. This bit is one of the fastest general purpose bits available.

**SPECIFICATIONS**

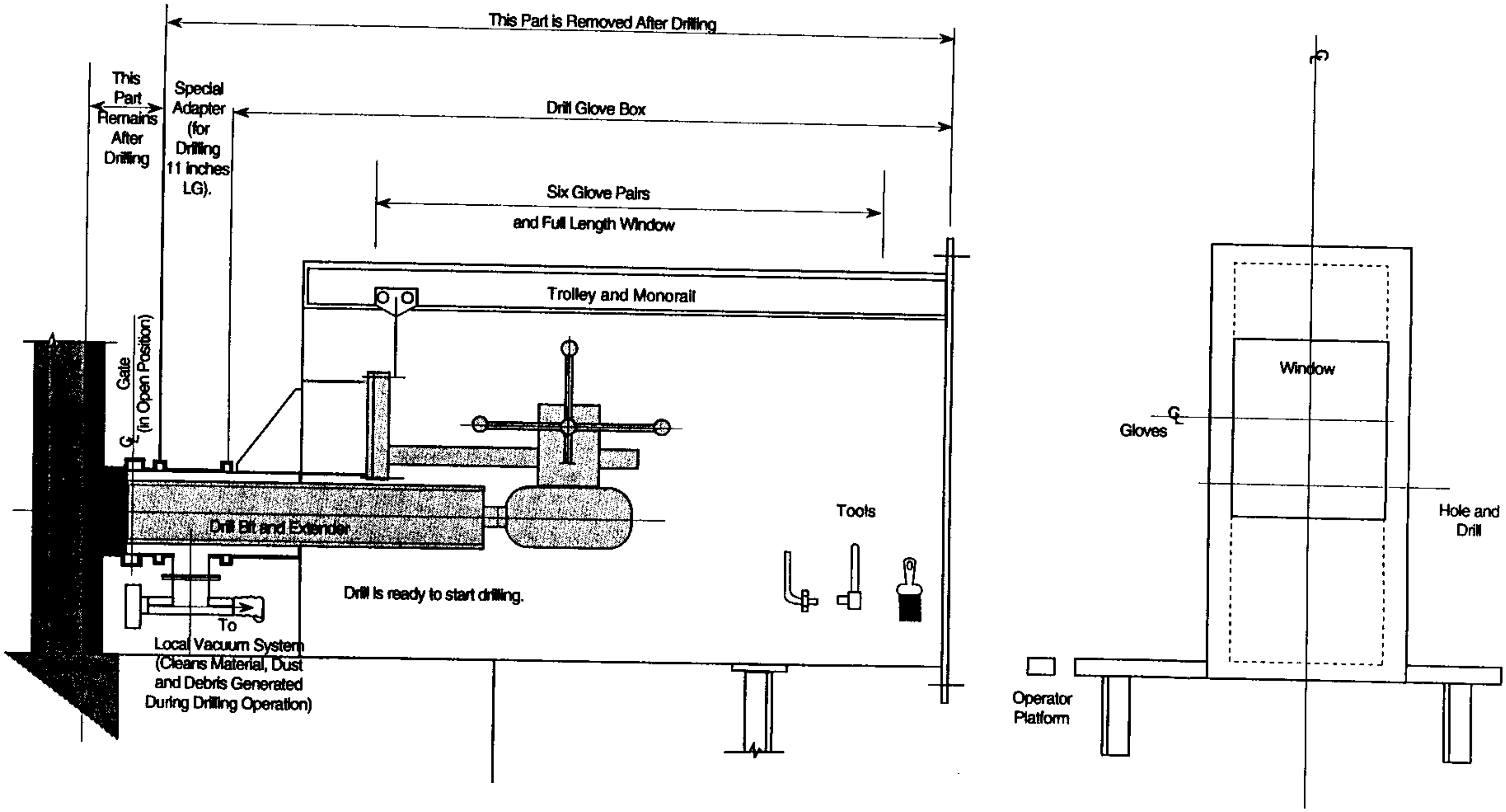
TH - General Purpose, Moderate Steel

Drill up to 30% faster with **Turbo** bits, Core Bore's newest drilling product. They cut faster and smoother because of their fluted segment design, which channels slurry better and reduces vibration. For high performance at competitive prices, choose Turbo bits.

Segmented bits are available in soft, medium, and hard bonds
All bits may be ordered with custom bonds
Used barrels may be recycled with our bit resegmenting program
x diameter available upon request

Standard drilling depth 13", any depth upon request
1/2" to 1-1/2" bits have 5/8"-11 hubs
1-5/8" bits and up have 1-1/4"-7 hubs
NOTE: ALL DIAMETERS ARE NOMINAL

ILLUS\OU-4\PO-161\DRILL BOX.EPS




Final details shall be discussed with the Drilling Contractor

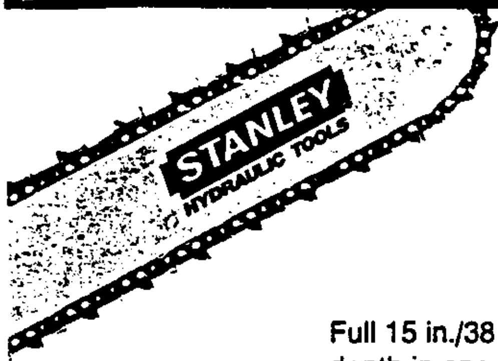
DRILL GLOVE BOX

CORE DRILLING ARRANGEMENT B-28

NOT TO SCALE

March 21, 1996

# DS11 Diamond Chain Saw



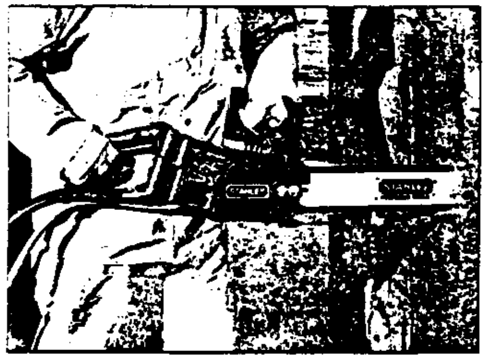

Five different chain types available.

High chain speed (5500 fpm).

Full 15 in./38 cm cut depth in one pass.

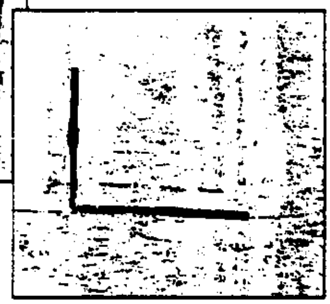
Chain segments impregnated with diamond and laser welded.

Conveniently placed bucking spikes provide cutting leverage.

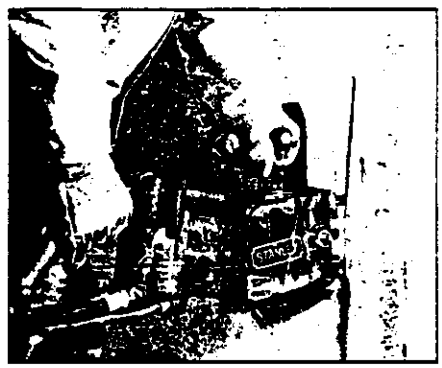


Plunge Cut

Corner Cut



Trim Cut



Slab Cut

water and operator comfort is enhanced. Water cooling and lubrication is routed internally along the entire length of the saw bar so you can achieve maximum penetration in the material during a plunge cut.

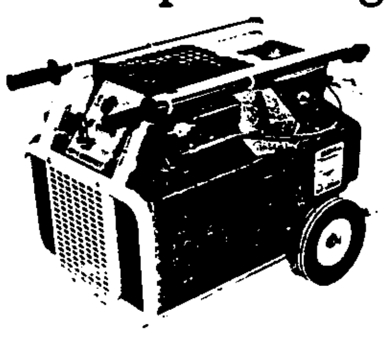
Conveniently placed bucking spikes provide cutting leverage to let the saw do the work, not the user. Ergonomically designed handles and guards help to reduce operator fatigue and provide protection from chain contact or abrasive material as it's being cut. A heavy duty cast aluminum chain guard prevents a loose or broken chain from being thrown from the saw.

The DS11 is fully compatible with HTMA (Hydraulic Tool Manufacturers Association) Class II hydraulic systems (8 gpm / 30 lpm at 2,000 psi/140 bar). Using hydraulics, the DS11 is quiet and smooth.

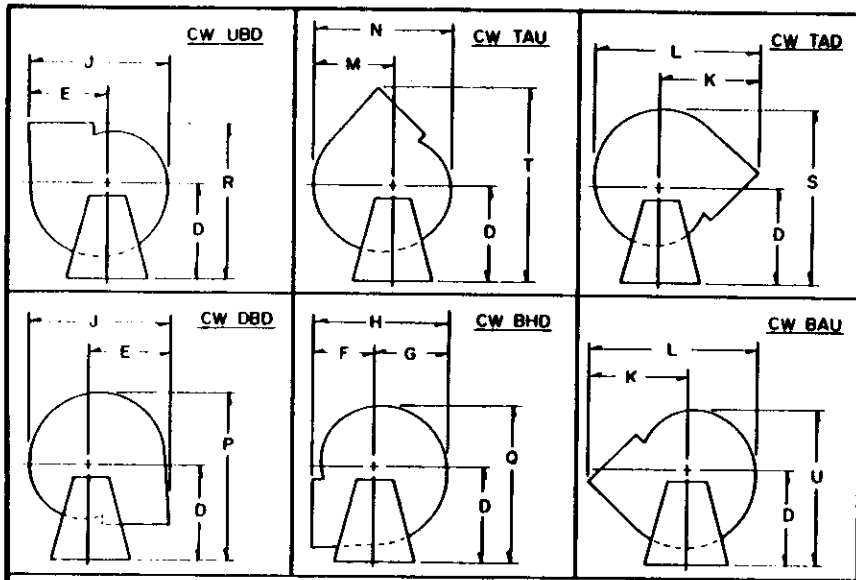
Because it's hydraulic, the internal components of the DS11 are sealed from the outside environment and constantly bathed in lubricating oil.

Long term storage can't hurt the DS11 either, because you thoroughly lube it each time you use it. There's no pre-storage prep or start-up hassles when the next season comes around.

# Portable power to get the job done fast



Team up our HP1 Compact Power Unit with the DS11 and you have all the power you need to get the job done fast — an ideal combination on job sites where space is limited or where hydraulic power just isn't available.




## NOTES:

1. CW ROTATION SHOWN. CCW ROTATION SIMILAR BUT OPPOSITE.
2. FOR MOTOR FRAME LARGER THAN MAXIMUM, USE CONSTRUCTION NO. 2.
3. ALL UNITS HAVE ROTATABLE HOUSINGS.
4. HOUSING MATERIAL:
   907-909, 12 GA. SIDES & SCROLL
   911-919, 10 GA. SIDES & SCROLL.
5. ARRANGEMENT NO. 1 IS SHOWN. ARRANGEMENT NO. 9 MOTOR IS MOUNTED ON SIDE OF PEDESTAL.

WHERE FLANGED INLET IS USED, SEE DWG. NO. BS-8790 FOR DIMENSION "W".

| SIZE | UNIT NO. | ROT. | DISCH. | MTR. H.P. | T.S. |
|---|---|---|---|---|---|
| CFM. | S.P. | RPM. | BHP. | O.V. | |

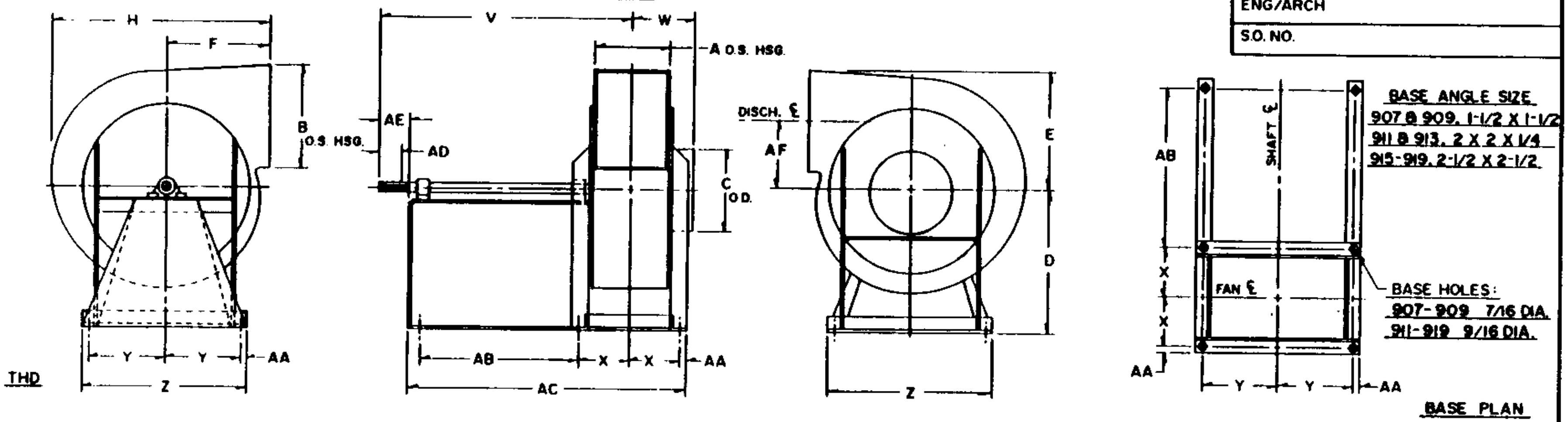
**ACCESSORIES REQ'D**

RBO, RBA, RBW ARRG. NO. 1 & 9 IND. FANS

TWIN CITY FAN & BLOWER
MINNEAPOLIS, MINNESOTA 55414

DRAWN: 11-17-81
REVISED:
DRG. NO.: AC-8410

| JOB |
|---|
| LOC. |
| CONT. |
| ENG/ARCH |
| S.O. NO. |




| SIZE | WHL DIA | A | B | C | D | E | F | G | H | SD SFT | SD KWY | HD SFT | HD KWY | J | K | L | M | N | P | O | R | S | T | U | V | W | X | Y | Z | AA | AB | AC | AD | AE | AF | MAX MTR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 907 | 12 1/4 | 6 1/16 | 6 13/16 | 7 | 14 1/4 | 10 9/16 | 8 5/16 | 9 11/16 | 18 | 1 3/16 | 1/4 x 1/8 | 1 7/16 | 3/8 x 3/16 | 19 5/16 | 13 3/8 | 22 5/8 | 10 1/8 | 18 7/16 | 23 15/16 | 23 1/16 | 22 9/16 | 24 3/8 | 27 5/8 | 22 5/8 | 20 15/16 | 4 11/16 | 4 1/16 | 6 3/8 | 14 | 5/8 | 12 | 21 5/8 | 3 1/2 | 4 | 7 3/16 | 145T |
| 909 | 15 5/8 | 7 11/16 | 8 5/8 | 9 | 15 1/4 | 13 1/2 | 10 5/8 | 12 3/8 | 23 | 1 3/16 | 1/4 x 1/8 | 1 7/16 | 3/8 x 3/16 | 24 11/16 | 17 1/16 | 28 7/8 | 12 15/16 | 23 9/16 | 27 5/8 | 26 1/2 | 25 7/8 | 28 3/16 | 32 5/16 | 25 15/16 | 22 1/4 | 5 1/2 | 4 7/8 | 8 1/8 | 17 1/2 | 5/8 | 12 | 23 1/4 | 4 | 4 1/2 | 9 3/16 | 145T |
| 911 | 19 1/8 | 9 7/16 | 10 9/16 | 11 | 18 3/4 | 16 7/16 | 13 | 15 1/16 | 28 1/16 | 1 7/16 | 3/8 x 3/16 | 1 11/16 | 3/8 x 3/16 | 30 1/8 | 20 13/16 | 35 3/16 | 15 3/4 | 28 3/4 | 33 13/16 | 32 7/16 | 31 3/4 | 34 1/2 | 39 9/16 | 31 3/4 | 26 7/8 | 6 7/8 | 6 | 9 1/8 | 20 | 7/8 | 14 1/4 | 28 1/4 | 5 | 5 1/2 | 11 3/16 | 184T |
| 913 | 22 5/8 | 11 1/8 | 12 7/16 | 13 1/4 | 21 3/4 | 19 7/16 | 15 3/8 | 17 13/16 | 33 3/16 | 1 11/16 | 3/8 x 3/16 | 1 15/16 | 1/2 x 1/4 | 35 5/8 | 24 5/8 | 41 5/8 | 18 5/8 | 34 | 39 9/16 | 37 15/16 | 37 1/8 | 40 7/8 | 46 3/8 | 37 1/8 | 28 15/16 | 7 11/16 | 6 13/16 | 10 5/8 | 23 | 7/8 | 15 1/2 | 31 1/8 | 5 | 5 1/2 | 13 1/4 | 213T |
| 915 | 26 1/8 | 12 13/16 | 14 5/16 | 15 1/4 | 25 1/4 | 22 3/8 | 17 3/4 | 20 1/2 | 38 1/4 | 1 15/16 | 1/2 x 1/4 | 2 3/16 | 1/2 x 1/4 | 41 | 28 3/8 | 48 | 21 1/2 | 39 3/16 | 45 3/4 | 43 7/8 | 43 | 46 3/4 | 53 5/8 | 43 | 35 13/16 | 9 1/16 | 7 15/16 | 11 7/8 | 26 | 1 1/8 | 19 3/4 | 38 1/8 | 6 | 6 3/4 | 15 1/4 | 254T |
| 917 | 29 5/8 | 14 1/2 | 16 1/4 | 17 1/4 | 28 1/4 | 25 3/8 | 20 1/8 | 23 1/4 | 43 3/8 | 1 15/16 | 1/2 x 1/4 | 2 3/16 | 1/2 x 1/4 | 46 1/2 | 32 3/16 | 54 3/8 | 24 5/16 | 44 3/8 | 51 1/2 | 49 7/8 | 48 3/8 | 52 5/8 | 60 9/16 | 48 5/16 | 38 5/8 | 9 7/8 | 8 3/4 | 13 1/2 | 29 1/4 | 1 1/8 | 21 3/4 | 41 3/4 | 6 | 6 3/4 | 17 1/4 | 256T |
| 919 | 33 | 16 1/8 | 18 1/16 | 19 1/4 | 31 1/4 | 28 1/4 | 22 7/16 | 25 7/8 | 48 5/16 | 2 3/16 | 1/2 x 1/4 | 2 7/16 | 5/8 x 5/16 | 51 3/4 | 35 7/8 | 60 9/16 | 27 1/16 | 49 7/16 | 57 1/8 | 54 3/4 | 53 11/16 | 58 3/8 | 67 1/8 | 53 5/8 | 43 | 10 11/16 | 9 9/16 | 14 3/8 | 31 | 1 1/8 | 24 1/4 | 45 7/8 | 7 | 7 3/4 | 19 1/4 | 286T |

# APPENDIX C

# DOSE ESTIMATE AND SHIELDING CONSIDERATIONS

# APPENDIX C

This appendix supports the Conceptual Design and the ALARA review (to be conducted by FERMCO), and prepares for the Title Design effort. It identifies established guidance and conservative assumptions to evaluate the direct gamma exposure impacts of the silo residues and their retrieval in the various operations and facilities. The product is an "order of magnitude" conservative estimate of potential direct exposures to radioactive materials encountered for installation and normal residue retrieval operations/maintenance of the Silos 1 and 2 superstructure and equipment room (ER), and the side access equipment enclosure (EE) for Silo 3. After development of the external source terms and exposure rates the use of shielding as an engineering control for the ER is determined. Further qualitative analysis is performed for inhalation exposures and their controls.

## C.1 Direct Exposure

The approach to determine the direct exposure is to develop a source term which calculates potential external exposure sources. The silo materials have two contributing sources - inherent radioactive components of the residue, and radon and decay daughters diffusing to the silo headspace. This study quantifies direct exposure modeling for those areas where workers are expected in proximity to the silo or to be in the ER/EE.

Direct exposure modeling uses a United States Department of Energy (DOE)-accepted method, namely Microshield Version 4 (MS4 1992) computer model. To accurately model the scatter of gamma rays with materials between the source and receptor the geometric progression buildup factor was used to account for scattered flux, as this is the most current method (MS4 1992). The results for each component were optimized by balancing the degree of integration for parameters, computer run time, and precision of the results.

### C.1.1 Calculation Basis

1) As determined by the Operable Unit 4 (OU-4) Remedial Investigation (RI) sample data for the silos (DOE 1993), the source with the highest radiation concentration per mass of solids is Silo 1. Thus, Silo 1 residues are used to model external exposure due to the residues for processes in the ER in proximity to Silos 1 and 2. The external exposure for the EE is modeled using the RI data for Silo 3.

2) For the ERs, both atop the Silos 1 and 2 superstructure, and the side access EE for Silo 3, the dose rate was determined for the two contributing factors of radon in the headspace and the residues.

3) The radioactive components of both the silo residues and the headspace with radon and decay daughters are assumed to be homogeneously mixed throughout their respective source volume for each case run in Microshield.

4) The average radionuclide concentrations from Silo 1 is used. While the OU-4 RI data indicate the residues are not homogeneously distributed and the radium concentration generally increases with depth in the silo, the residue retrieval methods mix the materials. This is accomplished by residue slurrying producing a slope where materials are directed into the slurry pool by the water jets (PARSONS 1996).

5) Two components are identified that contribute to the radon release rate. The first component is the radon continuously generated (radon flux rate) by the radium present in the residues. The second component is the radon retained by the material (resident radon) being released through residue retrieval activities (i.e., sluicing and pumping). The second term can be neglected for the development of an exposure rate because personnel should not be in the ER during residue retrieval.

6) The radon flux rate from the silo residues is evaluated for existing percent moisture. This provides a conservative value because the diffusion coefficient, as calculated by the material's moisture content, decreases with increasing moisture content.

7) It is assumed that 100 percent of radon retained by the waste material is released due to residue retrieval activities of the unsubmerged water jets for Silos 1 and 2. The quantity of residue slurried and removed is used as the control mass to determine radon released. This provides a bounding value for the dose rate from the silo headspace.

8) This calculation did not consider internal and background radiation dose rate factors.

### C.1.2 Analysis of Change in Silo Headspace/Residue Volumes

As the residue retrieval progresses for day to day operations, the silo headspace increases and the residue volume decreases. The volumetric changes for these two source terms need to be evaluated. The decrease in residue volume causes the exposure rate from the residue to decrease. Intuitively, the distance increasing from the residue to the receptor (in this case a worker in the ER) decreases the exposure rate. The smaller volume yields a smaller source term. However, corresponding to this the radon headspace term increases with a greater volume. The change in silo headspace volume and how this affects the equilibrium concentration of the radon with the Radon Treatment System (RTS) operating is not as simplistic as that for the residues. To determine the impact of this change the radon concentration in K-65 silos headspace can be determined using General Dilution Ventilation Equation (ACGIH 1995) as follows:

Rate of Accumulation = Rate of Generation - Rate of Removal

or

$$V*dC = G*dt - Q*C*\epsilon*dt \tag{1}$$

where:

V = Volume of headspace, $ft^3$
C = Radon concentration in headspace, pCi/l
G = Rate of radon generation, pCi/s
Q = RTS flow rate, cfm, (1000)
$\epsilon$ = RTS radon removal efficiency, (80 percent)
t = Time, min

The change in headspace volume can be determined as following

$$V = V_i + q*t \tag{2}$$

where:

$V_i$ = Initial volume of headspace, $ft^3$, (48000 for Silo 1 and 38000 for Silo 2 [DOE 1993])
q = Rate of silos residue removal, cfm

Equation 1 yields

$$(V_i + q*t)*dC = G*dt - Q*C*\epsilon*dt \tag{3}$$

Rearranging the differential material balance results in

$$dt / (V_i + q*t) = dC / (G - Q*C*\epsilon) \tag{4}$$

Which can be integrated to yield

$$(1/q) \ln (V_i + q*t) = -(1/Q*\epsilon) \ln (G - Q*C*\epsilon) \text{ or}$$

$$\ln (V_i + q*t)^{(-Q*\epsilon/q)} = \ln (G - Q*C*\epsilon)$$

Which yields

$$G - Q^*C^*\epsilon = (V_i + q^*t)^{(-Q^*\epsilon/q)} \tag{5}$$

Considering a K-65 slurry removal rate of 92.6 - 185.2 gpm (PARSONS 1995) or 13-25 cfm results in

$Q^*\epsilon/q >> 1$ and

$(V_i + q^*t)^{(-Q^*\epsilon/q)} \longrightarrow 0.0$

and Equation 5 results in

$$G - Q^*C^*\epsilon = 0 \tag{6}$$

Equation 6 indicates that radon concentration in headspace (C) will remain fairly constant during slurry removal operation and change in headspace volume has minimal effect on radon concentration in silos headspace.

### C.1.3 Determination of Silo Headspace Radon Concentration

The radon concentration used to determine the external exposure in the silo headspace from radon and short lived daughters is based on an extension of the previous derivation of:

Rate of Accumulation = Rate of Generation - Rate of Removal

As shown previously with the Rate of Accumulation equal to 0, a constant concentration independent of headspace volume results, or

$$G = Q^*C^*\epsilon \tag{7}$$

where:

C = Radon concentration in headspace, pCi/l
G = Rate of radon generation, pCi/s
Q = RTS flow rate, cfm, (1000)
$\epsilon$ = RTS radon removal efficiency, (80 percent)

The rate of radon generation, G, is the product of the rate of radon generation (pCi/m$^2$-sec) and residue surface area (m$^2$). The RAECOM model was used to calculate the radon flux in the Fernald Environmental Management Project *Risk Assessment Work Plan Addendum* (DOE 1992), Subsection 6.3.2.2. To account for moisture, the diffusion coefficient is modified as for a radon diffusion coefficient based on the total pore space from Nuclear Regulatory Commission (NRC) Regulatory Guide 3.64 (NRC 1989).

Solving this equation results in an equilibrium concentration of 2.5 E 6 pCi/l. This value is based on an RTS flow rate of 1000 cfm and radon removal efficiency of 80 percent of the design basis for the existing RTS and is approximately 10 percent of the radon samples taken for Silos 1 and 2 (DOE 1993). A conservative estimate for radon removal is thereby obtained. This silo headspace inventory is greater than that calculated as part of the design of the existing RTS (Grumski 1988).

### C.1.4 Comparison of Survey Data to Microshield Models

To determine a quantitative relationship between the exposure rate estimates calculated with Microshield runs and actual exposure rates, actual monitoring data from the Silo 2 dome for which surveys had been completed is modeled. Based on survey data from December 12, 1995 (FERMCO 1996a) for Silo 2 having a radon headspace concentration of 5.91E6 pCi/l, Microshield runs are created representing the silo as a cylinder volume source. The survey data provided are typical of exposure rates observed for the silo domes. The Microshield exposure rate for 30 cm from the dome surface is 40 millirem (mrem)/hr at the dome center and 29 mrem/hr at 35 feet from the center as compared to the survey data value of 25 mR/hr at 30 cm from the dome surface (location unknown), a difference of less than 15 percent. Though the model does compare well with the actual survey data, it should be realized that the results of the comparison are subject to many variables, and that without a known survey location on the silo dome, the variance between the observed survey data to that calculated may be less.

A related quantitative comparison was performed using the cylinder model and survey data from the operation of the existing RTS in 1987 and 1988 (FERMCO 1996b). This data showed the effect of running the RTS on the exposure rate at the Silo 1 Dome. An average exposure rate of approximately 100 mrem/hr was determined for the initial conditions prior to operation of the RTS. The contributing source factor from the residue as calculated by Microshield 4 was subtracted to yield an exposure rate approximately 50 mrem/hr. This was then used to back calculate a headspace concentration of 11.3E6 pCi/l. Comparing this value with that for the data from December 12, 1995, the exposure rate to headspace concentration ratios are within 5 percent agreement.

### C.1.5 Results of Direct Exposure and Associated Project Dose Budget

The results of the Microshield runs are incorporated into three tables. These results are based on a radon and daughters concentration of 2.5E6 pCi/l. For comparison, with the bentonite intact (assumed 1.5 ft thickness) the direct exposure for the residue is approximately 0.4 mR/hr.

Table C-1 provides the impact of two differing shielding thicknesses for the superstructure mounted ERs. The exposures are based on the radon headspace and residue sources. The greatest exposure rates occur at the dome centerline and are given here as conservative values. The residue source is significant once the bentonite is removed as part of the residue slurrying process. Other exposure rate estimates are provided as insight into the impact of location when determining the exposure rate.

Table C-2 tabulates the total direct exposure for the project predicted for personnel performing various operations in the Silo 1 and 2 ERs. Routine operations such as maintenance and activities requiring personnel to be present are presented in this table. The frequency, duration, and personnel required are included in the development of the dose budget. Operations performed prior to the start of the residue retrieval operations have lower exposure values due to the presence of the bentonite and use of the existing RTS. The reduction in external exposure is best afforded by wetting or "healing" the bentonite water and running the existing RTS to reduce the radon concentration in the silo headspace.

Table C-3 tabulates the project direct dose predicted for personnel performing various operations in preparation of the Silo 3 EE, and penetration and cutting of the Silo 3 wall. Routine operations such as maintenance and activities requiring personnel to be present are presented in this table. The frequency, duration, and personnel required are included in the development of the dose budget. It should be noted the external exposure rate increases as the residue retrieval progresses. This is a result of radon contained in the silo headspace contributes a larger external exposure source than the metal oxide residues.

## C.2 Inhalation Exposure

The exposure due to inhalation is evaluated qualitatively for the individual activities of both Silos 1 and 2 ERs and the EE located on the side of Silo 3. Those activities not in the silo ERs/EEs were not considered a potential inhalation source because the ER designs incorporates directed airflows. For Silos 1 and 2 ERs, the direction is from areas with no contamination (ambient outside, through the vestibule and into the ER) and finally to those with the highest (the silo interior). The radon laden air from the headspace is then treated at the New Radon Treatment System (NRTS). Silo 3 residue retrieval uses a pneumatic system that will entrain the radon with the light powdery residues. Once daily operations end potential radon leaks from both the hydraulic and pneumatic retrieval systems are very low because the lines are either backflushed or purged with clean air, respectively.

Residue retrieval operations in the Silos 1 and 2 ERs, and Silo 3 EE are remotely controlled and personnel are not present in the ER for these operations. High-Efficiency Particulate Air filters connected to the ER and Silo dome are used to filter particulates. The airflow for the Silo 1 and 2 ERs is directed from the external environment to the ER and then to the silo to prevent the release of particulates and radon gas. For Silo 3 the EE is initially isolated from the radon source term contained in the silo headspace. Airflow is vented from the silo headspace and the Silo 3 EE to limit radon buildup. Operational features for airflow and remote residue retrieval are presented in Subsections 2.7 and 3.5 for Silos 1 and 2 ER, and Silo 3 EE, respectively. Once the pneumatic retrieval system is in use, the ventilation system for the silo dome serves to confine the radon from the EE via directional airflow and pressure control. The system has further capabilities to use the NRTS if radon concentrations are determined unacceptable for direct release to the atmosphere. Given the uncertainty of the radon gas diffusing and the possibility of the NRTS going down, breathing air will be supplied to the ERs/EEs as standard Personnel Protective Equipment.

## C.3 Recommendations

The limitations of this direct exposure rate analysis are due to a lack of information available on the NRTS design. The flow rate and efficiency assumed for the NRTS should be confirmed at the earliest stages of NRTS design. Following on this thought, as part of the NRTS design a more detailed analysis should be performed for the equilibrium concentration radon. Other information gained from the NRTS design that should be incorporated into the project dose budget is the time to re-establish an equilibrium concentration once the daily residue retrieval operations are completed. An estimate would then be available for how long personnel would wait prior to entering the ER.

An As Low As Reasonably Achievable (ALARA) Design Review should be performed at the completion of the conceptual design. The ALARA Design Review should incorporate a cost-benefit analysis to determine an optimum shielding thickness based on work activities in the ER.

## Calculation 4161-56-02

**Table C-1 - Dose Rate Estimates for workers in ER (Centerline Above Silo Dome)**

| Waste Height (ft) | Headspace Height (ft) | Steel Shield Thickness (in) | Dose Rate from Waste (mrem/hr) | Dose Rate from Radon (mrem/hr) | Total Dose Rate (mrem/hr) |
|---|---|---|---|---|---|
| 23 | 8.1 | 2 | 8.9 | 1.0 | 9.9 |
| | | 1 | 18.2 | 2.9 | 21.1 |
| 18 | 13.1 | 2 | 8.6 | 1.7 | 10.3 |
| | | 1 | 17.4 | 4.6 | 22.0 |
| 13 | 18.1 | 2 | 8.2 | 2.3 | 10.5 |
| | | 1 | 16.2 | 6.2 | 22.4 |
| 8 | 23.1 | 2 | 7.7 | 2.8 | 10.5 |
| | | 1 | 14.9 | 7.5 | 22.4 |
| 3 | 28.1 | 2 | 7.2 | 3.3 | 10.5 |
| | | 1 | 13.6 | 8.8 | 22.4 |

**Other dose rate estimates**

| Description | Shielding Material | Thickness (in) | Dose Rate (mrem/hr) |
|---|---|---|---|
| Top dose @ 4 ft beyond silo side along manway | steel | 0.25 | 14.4 |
| Side contact dose from existing residue | soil | 68 | 7.20E-06 |
| Side contact dose with + 20 ft headspace | soil | 68 | 6.32E-06 |
| 10 meter side dose from headspace with no soil | n/a | n/a | 2.8 |

Notes:

1. These values are based on Silo 1 residue concentrations from the RI/FS.

**Table C-2 - Total Person-Rem Budget for Silo 1 and 2 Superstructure Operation during Residue Retrieval**

| | Period | Evolutions | Workers | Duration (hours) | Total Time (man-hrs) | Exposure Location | Exposure (mrem/hr) | Total Dose (mrem) |
|---|---|---|---|---|---|---|---|---|
| S/S INSTALLATION | | | | | | | | |
| Superstructure Erection | n/a | 1 | 5 | 20 | 100 | S/S | 2 | 200 |
| ER Mech Sys. Connection | n/a | 1 | 3 | 30 | 90 | ER | 2 | 180 |
| ER Elec Sys Connections | n/a | 1 | 3 | 30 | 90 | ER | 2 | 180 |
| NRTS Duct Connections | n/a | 2 | 2 | 10 | 40 | Dome | 2 | 80 |
| Water Jet Installation | n/a | 2 | 2 | 6 | 24 | Dome | 2 | 48 |
| System Checkout & Testing | n/a | 1 | 3 | 60 | 180 | ER | 2 | 360 |
| TOTAL | | | | | | | | 1048 |
| DOME PENETRATION | | | | | | | | |
| Install Dome Supports | n/a | 20 | 1 | 1 | 20 | Dome | 2 | 40 |
| Install Outer Seal | n/a | 4 | 1 | 2 | 8 | Dome | 2 | 16 |
| Install Floor Plates | n/a | 1 | 2 | 0.5 | 1 | Dome | 2 | 2 |
| Line ER w/ plastic | n/a | 1 | 1 | 2 | 2 | ER | 2 | 4 |
| Dome Segment Removal | n/a | 1 | 2 | 6 | 12 | ER | 2 | 24 |
| Silo/ER Insert Installation | n/a | 1 | 2 | 6 | 12 | ER | 2 | 24 |
| Remove cement segmet | n/a | 1 | 2 | 4 | 8 | ER | 2 | 16 |
| Clean ER (remove plastic) | n/a | 1 | 1 | 4 | 4 | ER | 2 | 8 |
| TOTAL | | | | | | | | 134 |
| BERM REMOVAL | | | | | | | | |
| Lower berms, phase 1 | n/a | 1 | 4 | 45 | 180 | Berm | 4 | 720 |
| Seal silo walls, phase 1 | n/a | 1 | 2 | 20 | 40 | Berm | 12 | 480 |
| Lower berms, phase 2 | n/a | 1 | 4 | 85 | 340 | Berm | 4 | 1360 |
| Seal silo walls, phase 2 | n/a | 1 | 2 | 20 | 40 | Berm | 12 | 480 |
| TOTAL | | | | | | | | 3040 |
| NON-ROUTINE OPERATIONS | | | | | | | | |
| Deploy Marconaflo | n/a | 2 | 1 | 4 | 8 | ER | 20 | 160 |
| Recover Marconaflo | n/a | 2 | 1 | 4 | 8 | ER | 20 | 160 |
| Changeout Marconaflo | n/a | 1 | 2 | 12 | 24 | ER | 20 | 480 |
| Install Houdini | n/a | 2 | 2 | 16 | 64 | ER | 20 | 1280 |
| Deploy Houdini | n/a | 2 | 1 | 4 | 8 | ER | 20 | 160 |
| Recover Houdini | n/a | 2 | 1 | 4 | 8 | ER | 20 | 160 |
| Transfer Houdini | n/a | 2 | 2 | 16 | 64 | ER | 20 | 1280 |
| TOTAL | | | | | | | | 3680 |
| ROUTINE OPERATIONS | | | | | | | | |
| Radiological Surveys | quarterly | 12 | 1 | 1 | 12 | ER | 20 | 240 |
| Camera Maintenance | quarterly | 12 | 1 | 1 | 12 | ER | 20 | 240 |
| Hoist/Monorail Maintenance | quarterly | 12 | 1 | 1 | 12 | ER | 20 | 240 |
| Marconaflo Maintenance | semi | 6 | 2 | 1 | 12 | ER | 20 | 240 |
| Relamp ER | annual | 3 | 1 | 1 | 3 | ER | 20 | 60 |
| TOTAL | | | | | | | | 1020 |
| ER TOTAL (For all activities identified ER) | | | | | | | | 5496 |
| GRAND TOTAL | | | | | | | | 8922 |

**Table C-3 - Total Person-Rem Budget for Silo 3 Operation during Residue Retrieval**

| | Period | Evolutions | Workers | Duration (hours) | Total Time (man-hrs) | Exposure Location | Exposure (mrem/hr) | Total Dose (mrem) |
|---|---|---|---|---|---|---|---|---|
| EE INSTALLATION | | | | | | | | |
| Groundwork Preperation | n/a | 1 | 5 | 40 | 200 | Silo side | 0.1 | 20 |
| Mech Sys Connection | n/a | 1 | 3 | 30 | 90 | EE | 0.1 | 9 |
| Elec Sys Connections | n/a | 1 | 3 | 30 | 90 | EE | 0.1 | 9 |
| Auger/Conveyor Prep | n/a | 2 | 2 | 20 | 80 | EE | 0.1 | 8 |
| System Checkout & Testing | n/a | 1 | 3 | 60 | 180 | EE | 0.1 | 18 |
| TOTAL | | | | | | | | 64 |
| SILO PREPARATION | | | | | | | | |
| Install EE | n/a | 1 | 4 | 40 | 160 | EE | 0.1 | 16 |
| Install Dome Vent/Cameras | n/a | 2 | 2 | 6 | 24 | Dome | 10 | 240 |
| TOTAL | | | | | | | | 256 |
| NON-ROUTINE OPERATIONS | | | | | | | | |
| Deploy Auger/Conveyor | n/a | 1 | 2 | 8 | 16 | EE | 1 | 16 |
| Remove Auger/Conveyor | n/a | 1 | 2 | 8 | 16 | EE | 1 | 16 |
| Deploy Pneumatic Sys | n/a | 1 | 2 | 8 | 16 | EE | 1 | 16 |
| Remove Pneumatic Sys | n/a | 1 | 2 | 8 | 16 | EE | 1 | 16 |
| Silo Wall Cutting | n/a | 1 | 2 | 8 | 16 | EE | 1 | 16 |
| Install Houdini | n/a | 2 | 2 | 16 | 64 | EE | 1 | 64 |
| Deploy Houdini | n/a | 2 | 1 | 4 | 8 | EE | 1 | 8 |
| Recover Houdini | n/a | 2 | 1 | 4 | 8 | EE | 1 | 8 |
| Transfer Houdini | n/a | 2 | 2 | 16 | 64 | EE | 1 | 64 |
| TOTAL | | | | | | | | 224 |
| ROUTINE OPERATIONS | | | | | | | | |
| Radiological Surveys | quarterly | 12 | 1 | 1 | 12 | EE | 1 | 12 |
| Silo Camera Maintenance | quarterly | 12 | 1 | 1 | 12 | EE | 5 | 60 |
| Monorail Maintenance | quarterly | 12 | 1 | 1 | 12 | EE | 1 | 12 |
| Retrieval Sys Maintenance | semi | 6 | 2 | 1 | 12 | EE | 1 | 12 |
| ER Relamp & Camera Maint | annual | 3 | 1 | 3 | 9 | EE | 1 | 9 |
| TOTAL | | | | | | | | 105 |
| Silo 3 EE TOTAL | | | | | | | | 357 |
| GRAND TOTAL | | | | | | | | 649 |

Note:
1. Dose rates for Installation Operations are performed prior to change in residue and headspace volumes.
2. Cutting silo wall is performed once initial residue residue retrieval has been completed.
3. Dose Rate increases are due to the modeling of a larger contributing factor from radon in the silo headspace.

## C.4 References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